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Savannah District

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THIS SOLICITATION IS UNRESTRICTED PURSUANT TO THE
"BUSINESS OPPORTUNITY DEVELOPMENT REFORM ACT OF 1988"
(PUBLIC LAW 100-656)

U.S. ARMY ENGINEER DISTRICT, SAVANNAH
CORPS OF ENGINEERS
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PROJECT TABLE OF CONTENTS

-- End of Project Table of Contents --

SECTION 16010

BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. This section forms an integral part of each Electrical sections included in Division 16 of the specifications.

B. Examine Drawings and other Sections of Specifications for requirements that affect work of this Section.

1.2 CONTRACT DOCUMENTS

A. Except where modified by a specific notation to the contrary, it shall be understood that the indication and/or description of any item, in the drawings or specifications or both, carries with it the instruction to furnish and install the item, regardless of whether or not this instruction is explicitly stated as part of the indication or description.

B. Items referred to in singular number in Contract Documents shall be provided in quantities necessary to complete work.

C. Drawings are diagrammatic. They are not intended to to show every offset, fitting, and component. The purpose of the drawings is to indicate a systems concept, the main components of the systems, and the approximate geometrical relationships. Based on the systems concept, the main components, and the approximate geometrical relationships, the contractor shall provide all other components and materials necessary to make the systems fully complete and operational.

D. Information and components shown on riser diagrams, but not shown on plans, and vice versa, shall apply or be provided as if expressly required on both.

E. Data that may be furnished electronically by the Contracting Officer (on computer tape, diskette, or otherwise) is diagrammatic. Such electronically furnished information is subject to the same limitation of precision as heretofore described. If furnished, such data is for convenience and generalized reference, and shall not substitute for sealed or stamped construction documents.

1.3 RFI'S

A. If Contractor requests clarifications of a conflict, or additional detail, Contractors shall include a sketch or equivalent description of Contractor's proposed solution.

1.4 SUBMITTALS

Government approval is required for submittals with a “G” designation; submittals not having a “G” designation are for information only. When usd, a designation following the “G” designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

*8

Record Drawings; G, RE~~AE~~
Coordination Drawings; G, RE~~AE~~
Short Circuit and Protection Coordination Studies; G, AE
Motor Starting Study; G, AE

SD-06 Test Reports

Independent Test Lab Report; G, RE

SD-10 Operation and Maintenance Data

Project Close-out Form; G, RE

A. General: The following information and requirements are intended to supplement Section 01330.

B. Definitions:

1. Coordination Drawings are a type of SD-02 detailed, large-scale layout Drawings showing HVAC, Electrical, Plumbing and Fire Protection work superimposed in order to identify conflicts and ensure inter-coordination of Mechanical, Electrical, Architectural, Structural and other work.

C. Coordination Drawing Procedures and Format

1. Review submittal packages for compliance with Contract Documents and then submit for review. Submit transparency and two blue- or black-line reproductions of each Shop Drawing larger than 8½ x 11. Submit four sets of each smaller shop drawing. After review, transparency original of each large Shop Drawing and three sets of each small shop drawing will be returned with reviewer's marks.

2. Provide additional copies of reviewed shop drawings as required for full distribution.

3. Shop Drawings showing layouts of systems shall contain sufficient plans, elevations, sections, details and schematics to describe work clearly. They shall be 1:50 scale unless specified otherwise. Sheet metal shop drawings shall be 1:50 and shall indicate work of other Sections where physical clearances are critical and where interferences are possible. Provide larger scale details as necessary. Sheet metal drawings shall show elements of Architect's reflected ceiling plan, exposed ductwork, walls, partitions, diffusers, registers, grilles, fire dampers, sleeves and other aspects of construction as necessary for coordination.

4. ALL FIREWALLS AND SMOKE PARTITIONS MUST BE HIGHLIGHTED ON THE SHEET METAL DRAWINGS FOR APPROPRIATE COORDINATION.

5. Shop drawings showing manufacturer's product data shall contain detailed dimensional drawings, accurate and complete description of materials of construction, manufacturer's published performance characteristics and capacity ratings (performance data, alone, is not acceptable), electrical requirements and wiring diagrams. Drawings shall clearly indicate location (terminal block or wire number), voltage and function for all field terminations, and other information necessary to demonstrate compliance with all requirements of Contract Documents.

1.5 COORDINATION DRAWINGS

A. Electrical drawings are diagrammatic. They are not intended to be absolutely precise; they are not intended to specify or to show every offset, fitting, and component. The purpose of the drawings is to indicate a systems concept, the main components of the systems, and the approximate geometrical relationships. Information and components shown on riser diagrams, but not shown on plans, and vice versa, shall apply or be provided as if expressly required on both. Based on the systems concept, the main components, and the approximate geometrical relationships, the contractor shall provide all other components and materials necessary to make the systems fully complete and operational.

B. Prepare coordination drawings as described in Section 15010, Basic Mechanical Requirements, to a scale of 1:20 or larger; detailing major elements, components, and systems of electrical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the work, including (but not necessarily limited to) the following:

1. Indicate the proposed locations of major raceway systems, equipment and materials. Include the following:

a. Clearances for servicing equipment, including space for equipment disassembly required for periodic maintenance.

b. Exterior wall and foundations penetrations.

c. Fire-rated wall and floor penetrations.

d. Equipment connections and support details.

e. Sizes and locations of required concrete pads and bases.

f. Location of all building/site ground connections/rods.

g. Locations of all access panels and access doors.

h. Control systems.

i. Lighting systems and fixtures.

j. Electrical Equipment Room Layouts.

k. Partitions/room layout.

l. Ceiling tile and grid.

m. Access panels.

n. Major electrical conduit runs, panelboards, feeder conduit and racks of branch conduit.

o. Above ceiling miscellaneous metal.

p. Civil and electrical underground utilities.

q. Electrical Distribution Systems and Equipment.

2. Indicate scheduling, sequencing movement and positioning of large electrical equipment into the building during construction.

3. Prepare floor plans, elevations and details to indicate penetrations in floors, walls and ceilings and their relationship to other penetrations and installations.

C. A single set of coordination drawings shall be mutually prepared by all mechanical and electrical trades.

D. The suggested initiation of these drawings begins with the Sheet Metal Shop Drawings as described in Section 15010 “Basic Mechaical Requirements”.

E. The contractor shall prepare a complete set of background drawings, showing structure and other information as needed for coordination. He shall show sheet metal layout thereon. These will be the Coordination Drawings.

F. Each of the mechanical, electrical and other specialty trades shall add its work to these background drawings with appropriate elevations and grid dimensions. Specialty trade information is required for fan rooms and mechanical rooms, horizontal exits from duct shafts, crossovers, and for spaces in and above ceilings where congestion of work may occur such as corridors, and even entire floors. Drawings shall indicate horizontal and vertical dimensions, to avoid interference with structural framing, ceilings, partitions, and other services.

G. Each specially trade shall sign and date each coordination drawing.

H. Where conflicts occur with placement of materials of various trades, the contractor will be responsible to coordinate the available space to accommodate all trades. Any resulting adjustments shall be initialed and dated by the specialty trade.

I. Installers who fail to promptly review and incorporate work on the drawings shall assume full responsibility of any installation conflicts affecting his work and of any schedule ramifications.

J. Sheet Metal Subcontractor shall make mylar transparencies of all coordination drawings. Fabrication shall not start until such transparencies of completed coordination drawings are received by the Architect/Engineer and have been reviewed.

K. Review of coordination drawings shall not diminish responsibility under this Contract for final coordination of installation and maintenance clearances of all systems and equipment with Architectural, Structural, Mechanical, Electrical and other work.

L. Distribution of Coordination Drawings:

1. The Contractor shall provide the following minimum distribution of documents:

a. One set of each Coordination Drawing to each specialty trade and affected Installer for their use.

b. One Mylar of each Coordination Drawing to Owner.

c. Coordination drawing to COR as described in Section 01330 “Submittals”.

M. All firewalls and smoke partitions must be highlighted on the coordination drawings for appropriate coordination.

N. The main paths of egress and for equipment removal, from main mechanical and electrical rooms must be clearly shown on the coordination drawings.

1.6 MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 1 Section "PROJECT CLOSEOUT." In addition to the requirements specified in Division 1, include the following information for equipment items:

1. Obtain at time of purchase of equipment, three copies of operation, lubrication and maintenance manuals for all items. Assemble literature in coordinated manuals with additional information describing combined operation of field assembled units, including as-built wiring diagrams. Manual shall contain names and addresses of manufacturers and local representatives who stock or furnish repair parts for items or equipment. Divide manuals into sections or books as follows:

a. Directions for and sequence of operation of each items of the Mechanical and Electrical systems, e.g. air handling units, boilers, domestic water pump, generator, etc. Sequence shall list valves, switches, and other devices used to start, stop and control system. Include detailed approved flow diagrams of temperature control, heating, chilled water, condenser water, etc., as appropriate for systems provided. Include approved valve directory showing each valve number, location of each valve, and equipment or fixture controlled by valve.

b. Description of equipment function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.

c. Manufacturer's printed operating procedures to include start-up, break-in, routine and normal operating instructions; regulation, control, stopping, shutdown, detailed procedures to follow in case of malfunction, and emergency instructions; and summer and winter operating instructions.

d. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.

e. Lubrication instructions detailing type of lubricant, amount, and intervals recommended by manufacturer for each item of equipment. Include additional instructions necessary for implementation of first class lubricant program. Include approved summary of lubrication instructions in chart form, where appropriate.

2. Furnish three copies of manuals to construction Manager for approval and distribution. Deliver manuals no less than 30 days prior to acceptance of equipment to permit Construction Manager designated personnel to become familiar with equipment and operation prior to acceptance.

3. Provide framed and glazed charts as follows: mount as directed by Construction Manager.

a. One line diagrams from first part of manual as described above.

b. Lubrication chart from third part of manual.

4. Operating instructions: Upon completion of installation or when Owner accepts portions of building and equipment for operational use, instruct Owner designated personnel in proper operation of all parts of the systems. Instructions shall be performed by factory-trained personnel. Refer to individual specification sections for additional requirements. Training sessions shall be video taped by the instructor. Provide two copies of the tapes to the Owner. Tapes shall be VHS format only.

1.7 ELECTRONIC FILES

A. Submittal materials which have been approved and been developed using computer software shall be submitted for the record in both hard copy as well as on electronic media. Microstation drawings shall be Microstation compatible and studies shall be Dapper and Captor (by SKM) compatible.

1.8 WARRANTEE AND 24 HOUR SERVICE

A. Guarantee the Work of Division 16 in writing for one year following the date of Substantial Completion. If the equipment is used prior to initial beneficial occupancy by the Owner, include an extended period of warranty covering one year following occupancy, starting from the initial date of beneficial use by the Owner. The guarantee shall repair or replace defective materials, equipment, workmanship, and installation that develop within this period, promptly and to COR’s satisfaction and correct damage caused in making necessary repairs and replacements under guarantee within the Contract Price.

B. In addition to guarantee requirements of Division 1 and of Paragraph A above, obtain written equipment and material warranties offered in manufacturer's published data without exclusion or limitation, in Owner’s designated name.

C. Provide 24 hour service beginning on the date of Substantial Completion and lasting until the termination of the guarantee period. Service shall be at no cost to the Owner. Service can be provided by installing contractor or a separate service organization. Choice of service organization shall be subject to Owner approval. Submit name and a phone number that will be answered on a 24 hour basis each day of the week, for the duration of the service.

D. Provide manufacturer's engineering and technical staff at the site to analyze and rectify problems that develop during guarantee period immediately.

PART 2 - PRODUCTS

2.1 QUALITY CONTROL

A. Factory Tests: Ensure that all materials and equipment specified in this Division have been given industry standard commercial tests prior to shipment.

B. UL Tests: Materials and equipment for which a UL standard exists shall be tested in accordance with the UL Standard and shall bear the UL label certifying satisfactory compliance with the listing standard.

2.2 CABLE TERMINATION TEMPERATURE RATINGS

A. All equipment terminations connecting to wire and cable, rated 600 V or less (see Section 16415A) shall be rated for 75E C, for conductors AWG #1 and smaller and/or where conductor ampacities are 100 A or less.

2.3 SHORT CIRCUIT AND PROTECTION COORDINATION STUDY

A. Submit shop drawings of complete short circuit and protection coordination studies with coordination plots for each medium and low voltage distribution system. Studies shall include:

1. Main primary and secondary short circuit ampacity and respective relay characteristics.
2. All breaker and relay final settings.
3. Base quantities selected.
4. Impedance source data.
5. Calculation methods and tabulations.
6. Voltage drop calculations.
7. One-line diagrams and impedance diagrams.
8. Coordination plots.
9. Conclusion and recommendations.
10. Ground fault studies for each system.

B. Ground fault studies shall include associated zero sequence impedance diagrams.

C. Short circuit momentary duties, when applicable, and interrupting duties shall be calculated on basis of assumed fault at each medium voltage switchgear line-up, low voltage switchgear lineup, switchboard, motor control center, distribution panelboard, pertinent branch circuit panelboard and other significant locations throughout systems.

D. Short circuit tabulations shall include fault impedances, X to R ratios, asymmetry factors, kVA, symmetrical and asymmetrical fault currents.

E. Voltage drop calculations shall be provided for the entire system, from primary switchgear through the farthest downstream panelboards.

F. Coordination plots shall graphically indicate coordination proposed for all systems centered on full scale log-log forms. Coordination plots shall include:

1. Complete titles.

2. Representative one-line diagrams and legends.

3. Associated power company's relay or system characteristics.

4. Significant motor starting characteristics.

5. Complete parameters for power, network and substation transformers.

6. Complete operating bands for low voltage switchgear or switchboard circuit breaker trip devices, for fuses, if applicable, and for associated system load protective devices.

G. Coordination plots shall define types of protective devices selected, proposed coil taps, time dial settings and pick-up settings required.

H. Transformer damage curve shall be included for each transformer when selected protection device is not within associated parameters.

I. Low voltage power circuit breakers shall be separated from each other and associated primary protective device by 16 percent current margin for coordination and protection in event of secondary line-to-line faults. Medium voltage relays shall be separated by 0.4 second time margin when maximum three-phase fault flows, to ensure proper selectivity.

J. Protective device characteristics or operating bands shall be suitably terminated to reflect actual symmetrical and asymmetrical fault currents sensed by device.

K. All shop drawings shall be prepared with a network analysis program on a digital computer, and shall include complete fault calculations as specified herein for each proposed and final system configuration.

1. Source combinations shall include proposed and future power company feeders, large motors, or generators.

L. Note that Contract Documents indicate general requirements for motors, motor starting equipment medium voltage and low voltage equipment, etc., but additional specific characteristics of equipment furnished shall be determined in accordance with results of short circuit and protection coordination study.

1. Equipment design discrepancies and proposed corrective modifications if required shall be submitted with short circuit and protection coordination study with variations clearly noted on subsequent shop drawings.

2. Field settings, adjustments and minor modifications necessary for conformance with approved short circuit and protection coordination study shall be accomplished without additional expense to the Owner.

3. Equipment shop drawings shall not be submitted until short circuit and protection coordination study has been approved by Engineer. M Refer to Section 16475 for further information.

M. Refer to Section 16475 for further information.

PART 3 - EXECUTION

3.1 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment specifications in Divisions 2 through 17 for rough-in requirements.

3.2 ELECTRICAL INSTALLATIONS

A. General: Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements.

1. Coordinate electrical systems, equipment, and materials installation with other site components.

2. Verify all dimensions by field measurements.

3. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.

4. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.

5. Coordinate connection of electrical systems with exterior underground utilities and services. Comply with requirements of governing regulations and controlling agencies. Provide required connection for each service.

6. Provide systems, materials, and equipment to conform with approved submittal data, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer to completed coordination drawings and refer conflict to the Architects for review. See Division 1 Section "Construction Contract Changes" for submission requirements.

7. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. Connect equipment for ease of disconnecting, with minimum of interference with other installations.

8. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope and on specified installation elevations.

9. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for electrical installation.

10. Install systems, materials, and equipment level and plumb (except where pitch is required), parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.

11. Conduit shall run concealed except in mechanical rooms and areas where no ceilings exist. Openings shall be temporarily closed to prevent obstruction and damage before completion.

12. Avoid interference with structure and with work of other trades, preserving adequate headroom and clearing doors and passageways.

13. Install equipment so as to properly distribute equipment loads on building structural members provided for equipment support under other Sections.

3.3 RIGGING AND INSTALLATION OF EQUIPMENT

A. This contractor shall provide and arrange for all necessary rigging required to bring equipment into the various electrical rooms and to install equipment on pads.

B. All large equipment shall be disassembled into the smallest-possible-sized components by the electrical contractor to facilitate rigging into the buildings. If no existing building entry is large enough to allow passage of a component, the contractor shall coordinate with the Construction Manager all rework of entry points to allow passage. Contractor is responsible for removal of doors and walls around doors as needed to allow rigging and installation of equipment within buildings, for all affected buildings. After installation, contractor shall return entry points he has modified to their original configuration, unless otherwise instructed by the Owner.

C. Contractor shall take appropriate steps to avoid damage to the buildings and their contents during rigging and installation. Any damage shall immediately be repaired to the Construction Manager and Owner’s satisfaction.

D. Avoid interference with structure and with work of other Sections. Preserve adequate headroom and clear doors and passageways, as shown, noted or required herein and as required by codes. Installation shall permit clearance for access to equipment for repair, servicing and replacement.

E. Install equipment in a manner which distributes equipment loads properly on building structural members.

F. Provide hangers, brackets, anchors, guides and other devices for mounting of equipment provided under this contract.

G. Provide steel supports and hardware for proper installation of hangers, brackets, anchors, guides, and other devices.

H. Miscellaneous

1. Unload materials and equipment delivered to site. Pay costs for rigging, hoisting, lowering and moving electrical equipment and materials provided by this Section on and around site, in building or on roof.

I. Provide catalog cuts, weights, and other pertinent data required for proper coordination of equipment support provisions and installation.

J. Structural steel and hardware shall meet STM Standard Specifications requirements. Use of steel and hardware shall meet requirements of Code and practice of American Institute of Steel Construction.

K. Verify site conditions and dimensions of equipment to ensure access for proper installation of equipment without disassembly that nullifies warrantee. Report in writing to the Construction Manager before purchase or shipment of equipment involved on conditions which may prevent proper installation.

L. Controls

1. In accordance with Section 15951 for interfacing with the building control system.

3.4 CORE DRILLING

A. Core drilling is to be avoided.

B. Set sleeves prior to installation of structure for passage of pipes, conduit, ducts, etc.

C. Where core drilling is unavoidable, or required by renovation projects, locate all required openings prior to coring and submit to Architect for review.

D. Coordinate openings with and all other trades.

E. Do not disturb existing systems. Protect all areas from damage of any type.

F. Thoroughly investigate existing conditions in vicinity of required opening prior to coring.

3.5 PENETRATIONS AND SLEEVES

A. General:

1. Lay out penetration and sleeve openings in advance, to permit provision in work. Set sleeves and conduit in forms before concrete is poured. Provide remedial work where sleeves and conduits are omitted or improperly placed.

2. Provide sleeves and packing materials at all penetrations of foundations, walls, slabs (except on-grade), partitions and floors. Sleeves shall meet NFPA-101 requirements and materials requirements of these specifications.

3. Sleeves that penetrate outside walls, slabs, footings and beams shall be waterproof.

4. Coordinate work with other Sections. Set sleeves in forms before concrete is poured. Provide core drilling as necessary if walls are poured, or otherwise constructed, without sleeves and a wall penetration is required. Do not penetrate structural members.

5. Identify unused sleeves and slots for future installation.

6. Fill slots, sleeves and other openings in floors or walls if not used. Fill spaces in openings after installation of pipe, duct, conduit or cable.

7. Fill for floor penetrations shall prevent passage of water, smoke, fire, and fumes. Fill shall be fire resistant in fire floors and walls, and shall prevent passage of air, smoke and fumes.

8. Sleeves through floors shall be water-tight and shall extend 2” above floor surface.

9. Where conduits passing through openings are exposed in finished rooms, finishes of filling materials shall match and be flush with adjoining floor, ceiling, and wall finishes.

B. Pipe and Conduit Sleeves:

1. Annular space between pipe/conduit and sleeve shall be at least ¼”.

2. Sleeves are not required for slabs-on-grade unless specified otherwise.

3. Sleeves and packing materials, through rated fire walls and smoke partitions shall maintain fire rating of construction penetrated.

4. Do not support piping risers or conduit on sleeves.

C. Installation, Testing, Listings and Approvals

1. Installation shall meet material manufacturer's recommendations exactly, particularly as regards safety, ventilation, removal of foreign materials and other details of installation. Dam openings as recommended. Remove flammable materials used for damming and forming seals in fire-rated construction.

2. Sleeve penetration methods shall be water- and gas-tight and shall meet requirements of ASTM E-119 Standard Methods of Fire Test of Building Construction and Materials.

3. Fire-stop penetration seal methods and materials shall be FM-approved and UL-listed as applicable.

4. Inspect foamed sealants to ensure manufacturer's optimum cell structure and color ranges.

3.6 CLEANING

A. Cleaning shall be performed prior to commissioning. Provide in accordance with Division 1.

3.7 ACCESS AND ACCESS PANELS

A. Provide access to materials and equipment that require inspection, replacement, repair or service. Provide access panels and/or doors as required to allow service of all equipment components.

B. Coordinate and prepare a location, size, and function schedule of access panels required to fully service equipment and deliver to the Constructor Manager.

C. Ceilings consisting of lay-in or removable splined tiles do not require access panels. All components above lay-in ceilings shall have location marked with colored thumb tack on finished ceiling panel. Location shall be noted on record drawings.

D. Access panels shall have same fire rating classification as surface penetrated.

E. Panels shall be at least 300mm x 300mm, access panels at equipment shall be a minimum of 450mm x 450mm.

3.8 CONTINUITY OF SERVICES

A. Do not interrupt existing services without Contracting Officer’s approval.

B. Schedule interruptions in advance, according to Owner instructions. Submit, in writing, request for interruption, methods proposed to minimize length of interruption.

C. Interruptions shall be scheduled at such times of day and work so that they have minimal impact on operations.

D. Coordinate any shutdown of existing systems as follows:

1. Give proper notice to Contracting Officer when making shutdowns; a minimum of fourteen full days are required.

2. Minimize shutdowns of any system.

3. Provide temporary services where required and perform shutdowns and tie ins at a time convenient to the Owner.

4. Complete and file any Construction Manager required shutdown notice questionnaires.

5. Perform required survey and inspection work required by the notice for shutdown.

E. Include premium time work associated with interruptions of services and/or shutdowns as necessary to avoid disruption to operations.

3.9 TESTING OF ELECTRICAL SYSTEMS BY INDEPENDENT TESTING LAB

A. Work Included:

1. This Contractor shall engage the services of a recognized independent testing laboratory for the purpose of performing inspections, tests, and cleaning as herein specified.

2. The testing laboratory shall provide all material, equipment, labor and technical supervision to perform such tests and inspections.

3. It is the intent of these tests to insure that all electrical equipment, is operational within industry and manufacturer's tolerances and is installed in accordance with design specifications.

4. The tests and inspections shall determine the suitability for energization. Failure or defects in workmanship or materials revealed by the tests shall be corrected promptly and retested.

B. Specific Work Scope: The following referenced equipment shall be tested and cleaned in accordance with these specifications:

1. Switchgear – General

2. Transformers – Dry Type

3. Cables – Medium Voltage

4. Switchboard

5. Circuit Breakers – Low Voltage

6. Instrument Transformers

7. Metering and Instrumentation

8. Ground Fault System

9. Grounding System

10. Surge Arrestors

11. Variable Frequency Drives

12. Panelboards

13. Motor Control Centers

14. UPS

15. TVSS

16. Closed Transition Transfer Switch

17. All inspection, tests and cleaning shall be in accordance with the following applicable Codes and Standards, except as provided otherwise herein.

    a. National Electrical Code (NEC).

    b. National Electrical Manufacturer's Association (NEMA).

    c. American Society for Testing and Materials (ASTM).

    d. Institute of Electrical and Electronic Engineers (IEEE).

    e. National Electrical Testing Association (NETA).

    f. American National Standards Institute (ANSI).

    g. Insulated Power Cable Engineers Association (IPCEA).

    h. Association of Edison Illuminating Companies (AEIC).

    i. OSHA Part 19810; Sub-Part S, 1910.108.

18. All inspection and tests shall utilize the following references:

    a. Project design specifications.

    b. Project design drawings.

19. Manufacturer's instruction manual applicable to each particular product.

C. Qualification:

1. Testing laboratory shall meet Federal OSHA criteria for Accreditation of Testing Laboratories, Title 29, Part 1907.

2. The testing laboratory shall submit proof of the above qualifications.

D. Division of Responsibility:

1. This contractor shall perform routine insulation resistance, continuity and rotation tests for all distribution and

utilization equipment prior and in addition to tests performed by the testing laboratory specified herein.

2. This contractor shall supply a suitable and stable source of test power to the tests laboratory at each test site. The testing laboratory shall specify requirements.

3. This contractor shall notify the testing laboratory when equipment becomes available for acceptance tests. Work shall be coordinated to expedite project schedule.

4. This contractor will supply a complete set of electrical plans, specifications to the testing laboratory prior to commencement of testing.

5. Testing laboratory shall notify the COR prior to commencement of any testing.

6. Testing laboratory shall be responsible for implementing all final settings and adjustments on protective devices and tap changes in accordance with COR's specified values.

7. Any system material or workmanship which is found defective on the basis of acceptance tests shall be reported directly to the COR.

8. Testing laboratory shall maintain a written record of all tests and upon completion of project, assemble and certify a final test report.

E. Safety Precautions:

1. Safety practices shall include, but are not limited to the following requirements:

   a. Occupational Safety and Health Act of 1970 (OSHA).

   b. Accident Prevention Manual for Industrial Operations, Seventh Edition, National Safety Council, Chapter 4.

2. All acceptance tests shall be performed with apparatus de-energized, except where otherwise specifically required.

3. Testing laboratory shall have a designated safety representative who shall be present on the project and supervise operations with respect to safety.

4. Circuits operating in excess of 600 volts between conductors shall have conductors shorted to ground by hot-line grounded device approved for the purpose.

5. In all cases, work shall not proceed until safety representative has determined that it is safe to do so.

6. Testing laboratory shall have available sufficient protective barriers and warning signs to conduct specified tests safely.

F. Testing Equipment - Test Instrument Traceability:

1. Testing laboratory shall have a calibration program which maintains all applicable test instrumentation within rated accuracy.

2. Accuracy shall be traceable to National Bureau of Standards in an unbroken chain.

3. Instruments shall be calibrated in accordance with the following frequency schedule:

a. Field Instruments, six months maximum.

b. Laboratory Instruments, twelve months.

c. Leased Specialty Equipment, twelve months (where accuracy is guaranteed by lessor, i.e., Doble).

G. Test Report:

1. Test report shall include the following:

a. Summary of project.

b. Description of equipment tested.

c. Description of test.

d. List of test equipment used in calibration and calibration date.

e. Test results.

f. Conclusions and recommendations.

g. Appendix, including appropriate test forms.

2. Test report shall be bound and its contents certified.

3. Furnish five copies of the complete report to the Engineer no later than thirty days after completion of the project, unless directed otherwise.

H. Inspection and Test Procedure:

1. General:

a. Visual and Mechanical Inspection:

1) Inspect for physical damage.

2) Compare equipment nameplate information with latest single line diagram and report discrepancies.

3) Inspect for proper alignment, anchorage and grounding.

2. Procedures:

a. All inspections and testing shall be executed in complete compliance with Paragraph 7 of the National Electrical Testing Association's (NETA) acceptance testing specifications for electrical power distribution equipment and systems.

I. Refer to individual sections for further testing requirements.

PART 4 - EXECUTION

4.1 SPECIAL RESPONSIBILITIES

A. Cooperate and coordinate with work of other Sections in executing work of Division 16.

1. Perform work such that progress of entire project including work of other Sections shall not be interfered with or delayed.

2. Obtain detailed installation information from manufacturers of equipment provided under Division 16.

3. Obtain final roughing dimensions or other information as needed for complete installation of items furnished under other Sections or by Contracting Officer.

4. Keep fully informed as to shape, size and position of openings required for material or equipment to be provided under this and other Sections. Give full information so that openings required by work of these Divisions may be coordinated with other work and other openings and may be provided for in advance. In case of failure to provide sufficient information in proper time, provide cutting and patching or have same done, at own expense and to full satisfaction of Contracting Officer.

5. Provide information as requested as to sizes, number and locations of concrete housekeeping pads necessary for floor-mounted equipment provided under Division 16.

B. Maintenance of equipment and systems: Maintain equipment and systems until Final Acceptance. Ensure adequate protection of equipment and material during delivery, storage, installation and shutdown and during delays pending final test of systems and equipment because of seasonal conditions.

C. Surveys and Measurements:

1. Base measurements, both horizontal and vertical, on reference points established by Contractor and be responsible for correct laying out of work.

2. In event of discrepancy between actual measurements and those indicated, notify COR in writing and do not proceed with work until written instructions have been issued.

D. Temporary Utilities:

1. Refer to Division 1 regarding requirements.

2. Coordinate work under Division 15 with progress of construction so that permanent heating system will be ready to provide temporary heating if permitted by COR as soon as building is closed in.

3. Provide and direct labor required for attendance, operation and final restoration of permanent heating system if used for temporary heating purposes. Continuous direct attendance shall be provided whenever permanent system is in operation prior to acceptance of permanent heating system by Owner.

E. Miscellaneous

1. Unload materials and equipment delivered to site. Pay costs for rigging, hoisting, lowering and moving electrical equipment on and around site, in building or on roof.

4.2 PROJECT CLOSE-OUT PROCEDURE

A. General

1. The requirements of this Article are in addition to and supplement the requirements outlined in Division 1.

B. Project Close-Out Checklist

1. Review requirements of each section of the specifications and submit for approval to Architect the sign-off forms which shall become the project close-out checklist. These, at a minimum, shall include the following information shown in attached Project Closeout Checklist Example. The COR may incorporate additional specific items to the following checklist which shall become part of the project requirements.

2. Close-Out Checklist Example

PROJECT CLOSE-OUT			
PROJECT:			
DIVISION NO.:			
CONTRACTOR:			
ITEM[1]	DATES		SIGN-OFF
	COMPLETED	RECEIVED BY OWNER	
Permits			
Manufacturer’s Warranties			
Contractor’s Warranties			
State Fire Rating Data			
Copy of Final Shop Drawings			
List and Possession of Spare Parts			
Pressure Tests			
Equipment Tests Required by Specs			
O & M Manuals			
Record Documents			
Coordination Drawings			
Sanitization Reports			
Commissioning Reports/Letters/Forms			
On Site Training Complete			
Protective Device Settings			
Valve Tags and Charts			
Final Punch List (Initialed by contractor that items are complete)			
24 Hour Phone No. for Service During Guarantee Period			

END OF SECTION

[1] Provide separate line item for each specified item (do not group items).

SECTION TABLE OF CONTENTS

DIVISION 16 - ELECTRICAL

SECTION 16050N

BASIC ELECTRICAL MATERIALS AND METHODS

02/01

PART 3 EXECUTION

-- End of Section Table of Contents --

SECTION 16050N

BASIC ELECTRICAL MATERIALS AND METHODS
02/01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D709	(2000) Laminated Thermosetting Materials

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.147	Control of Hazardous Energy (Lock Out/Tag Out)

INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS (IEEE)

IEEE 100	(1996) Dictionary of Electrical and Electronics Terms (ANSI/IEEE)
IEEE C2	(1997) National Electrical Safety Code (ANSI/IEEE)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C57.12.28	(1999) Pad-Mounted Equipment - Enclosure Integrity (Revision of ANSI C57.12.28-88)
NEMA ICS 6	(1993) Industrial Control and Systems Enclosures
NEMA MG 1	(1998; Errata 1999) Motors and Generators
NEMA MG 10	(1994) Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
NEMA MG 11	(1977; R 1992) Energy Management Guide for Selection and Use of Single-Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1999) National Electrical Code

1.2 RELATED REQUIREMENTS

This section applies to certain sections of[Division 2, "Site Construction,"][Division 11, "Equipment,"][Division 13, "Special Construction,"][and][Division 15, "Mechanical"]. This section applies to all sections of Division 16, "Electrical," of this project specification unless specified otherwise in the individual sections.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE 100.

b. The technical sections referred to herein are those specification sections that describe products, installation procedures, and equipment operations and that refer to this section for detailed description of submittal types.

c. The technical paragraphs referred to herein are those paragraphs in PART 2 - PRODUCTS and PART 3 - EXECUTION of the technical sections that describe products, systems, installation procedures, equipment, and test methods.

1.4 ELECTRICAL CHARACTERISTICS

Electrical characteristics for this project shall be 12.47 kV primary, three phase, three wire, 60 Hz, and 480/277 volts secondary, three phase, four wire. Final connections to the power distribution system at the existing Sectionalizer Primary Cabinet shall be made by the Contractor as directed by the Contracting Officer.

1.5 SUBMITTALS

Submittals required in the sections which refer to this section shall conform to the requirements of Section 01330, "Submittal Procedures" and to the following additional requirements. Submittals shall include the manufacturer's name, trade name, place of manufacture, catalog model or number, nameplate data, size, layout dimensions, capacity, project specification and technical paragraph reference. Submittals shall also include applicable federal, military, industry, and technical society publication references, and years of satisfactory service, and other information necessary to establish contract compliance of each item to be provided. Photographs of existing installations are unacceptable and will be returned without approval.

1.5.1 Manufacturer's Catalog Data

Submittals for each manufactured item shall be current manufacturer's descriptive literature of cataloged products, equipment drawings, diagrams, performance and characteristic curves, and catalog cuts. Handwritten and typed modifications and other notations not part of the manufacturer's preprinted data will result in the rejection of the submittal. Should manufacturer's data require supplemental information for clarification, the supplemental information shall be submitted as specified for certificates of compliance.

1.5.2   Drawings

Submit drawings a minimum of 355 by 510 mm in size using a minimum scale of one mm per 100 mm[, except as specified otherwise]. Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices.

1.5.3   Instructions

Where installation procedures or part of the installation procedures are required to be in accordance with manufacturer's instructions, submit printed copies of those instructions prior to installation. Installation of the item shall not proceed until manufacturer's instructions are received. Failure to submit manufacturer's instructions shall be cause for rejection of the equipment or material.

1.5.4   Certificates

Submit manufacturer's certifications as required for products, materials, finishes, and equipment as specified in the technical sections. Certificates from material suppliers are not acceptable. Preprinted certifications and copies of previously submitted documents will not be acceptable. The manufacturer's certifications shall name the appropriate products, equipment, or materials and the publication specified as controlling the quality of that item. Certification shall not contain statements to imply that the item does not meet requirements specified, such as "as good as"; "achieve the same end use and results as materials formulated in accordance with the referenced publications"; or "equal or exceed the service and performance of the specified material." Certifications shall simply state that the item conforms to the requirements specified. Certificates shall be printed on the manufacturer's letterhead and shall be signed by the manufacturer's official authorized to sign certificates of compliance.

1.5.4.1   Reference Standard Compliance

Where equipment or materials are specified to conform to industry and technical society reference standards of the organizations such as American National Standards Institute (ANSI), American Society for Testing and Materials (ASTM), National Electrical Manufacturers Association (NEMA), Underwriters Laboratories (UL), and Association of Edison Illuminating Companies (AEIC), submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance.

1.5.4.2   Independent Testing Organization Certificate

In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contracting Officer. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard.

1.5.5 Operation and Maintenance Manuals

Comply with the requirements of Section 01781N, "Operation and Maintenance Data" and the technical sections.

1.5.5.1 Operating Instructions

Submit text of posted operating instructions for each system and principal item of equipment as specified in the technical sections.

1.6 QUALITY ASSURANCE

1.6.1 Material and Equipment Qualifications

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in the technical section.

1.6.2 Regulatory Requirements

Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70.

1.6.3 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.6.4 Service Support

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.6.5 Manufacturer's Nameplate

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

1.6.6 Modification of References

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer.

1.6.7 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.7 POSTED OPERATING INSTRUCTIONS

Provide for each system and principal item of equipment as specified in the technical sections for use by operation and maintenance personnel. The operating instructions shall include the following:

a. Wiring diagrams, control diagrams, and control sequence for each principal system and item of equipment.

b. Start up, proper adjustment, operating, lubrication, and shutdown procedures.

c. Safety precautions.

d. The procedure in the event of equipment failure.

e. Other items of instruction as recommended by the manufacturer of each system or item of equipment.

Print or engrave operating instructions and frame under glass or in approved laminated plastic. Post instructions where directed. For operating instructions exposed to the weather, provide weather-resistant materials or weatherproof enclosures. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal or peeling.

1.8 NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each panelboard, equipment enclosure, relay, switch, and device; as specified in the technical sections or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 3 mm thick, white with black center core. Provide red laminated plastic label with white center core for emergency/standby system. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be 25 by 65 mm. Lettering shall be a minimum of 6.35 mm high normal block style.

1.9 WARNING SIGNS

Provide warning signs for the enclosures of electrical equipment including substations, pad-mounted transformers, pad-mounted switches, generators, and switchgear having a nominal rating exceeding 600 volts.

a. When the enclosure integrity of such equipment is specified to be in accordance with NEMA C57.12.28, such as for pad-mounted transformers[and pad-mounted SF6 switches], provide self-adhesive warning signs on the outside of the high voltage compartment door(s). Sign shall be a decal and shall have nominal dimensions of 178 by 255 mm with the legend "DANGER HIGH VOLTAGE" printed in two lines of nominal 50 mm high letters. The word "DANGER" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall be in black letters on a white background. Decal shall be Panduit No. PPSO710D72 or approved equal.

b. When such equipment is guarded by a fence, mount signs on the fence. Provide metal signs having nominal dimensions of 355 by 255 mm with the legend "DANGER HIGH VOLTAGE KEEP OUT" printed in three lines of nominal 75 mm high white letters on a red and black field.

1.10 CABLE TAGS IN MANHOLES, HANDHOLES, AND VAULTS

Provide tags for each cable or wire located in manholes, handholes, and vaults. Tag new wire and cable provided under this contract and existing wire and cable which are indicated to have splices and terminations provided by this contract. The first position on the tag shall denote the voltage. The second through fourth positions on the tag shall identify the circuit. The next to last position shall denote the phase of the circuit and shall include the Greek "phi" symbol. The last position shall denote the cable size. Tag legend shall be as indicated. The tags shall be polyethylene. Do not provide handwritten letters. As an example, a tag could have the following designation: "11.5 NAS 1-8(Phase A)500," denoting that the tagged cable is on the 11.5kV system circuit number NAS 1-8, underground, Phase A, sized at 500 kcmil.

1.10.1 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of 22.4 MPa; and that are two millimeter thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 77 degrees C. Provide 1.3 mm (minimum) thick black polyethylene tag holder. Provide a one-piece nylon, self-locking tie at each end of the cable tag. Ties shall have a minimum loop tensile strength of 778.75 N. The cable tags shall have black block letters, numbers, and symbols 25 mm high on a yellow background. Letters, numbers, and symbols shall not fall off or change positions regardless of the cable tags' orientation.

1.11 ELECTRICAL REQUIREMENTS

Electrical installations shall conform to IEEE C2, NFPA 70, and requirements specified herein.

1.11.1 Motors and Equipment

Provide electrical components of mechanical equipment, such as motor starters, control or push-button stations, float or pressure switches, solenoid valves, and other devices functioning to control mechanical equipment, including control wiring and conduit for circuits rated 100 volts or less, to conform with the requirements of the section covering the mechanical equipment. Extended voltage range motors shall not be permitted. The interconnecting power wiring and conduit, control wiring rated 120 volts (nominal) and conduit, [the motor control equipment forming a part of motor control centers,] and the electrical power circuits shall be provided under Division 16.]

1.11.2 Wiring and Conduit

Provide internal wiring for components of packaged equipment as an integral part of the equipment. Provide power wiring and conduit for field-installed equipment[, and motor control equipment forming part of motor control centers or switchgear assemblies, the conduit and wiring connecting such centers, assemblies, or other power sources to equipment] under Section 16402N, "Interior Distribution System." Power wiring and conduit shall conform to Section 16402N, "Interior Distribution System." Control wiring and conduit shall be provided under, and conform to the requirements of the section specifying the associated equipment.

1.11.3 New Work

Provide electrical components of mechanical equipment, such as motor starters (except starters/controllers which are indicated as part of a motor control center), control or push-button stations, float or pressure switches, solenoid valves, integral disconnects, and other devices functioning to control mechanical equipment, as well as control wiring and conduit for circuits rated 100 volts or less, to conform with the requirements of the section covering the mechanical equipment. Extended voltage range motors shall not be permitted. The interconnecting power wiring and conduit, control wiring rated 120 volts (nominal) and conduit, the motor control equipment forming a part of motor control centers, and the electrical power circuits shall be provided under Division 16, except internal wiring for components of packaged equipment shall be provided as an integral part of the equipment. When motors and equipment furnished are larger than sizes indicated, provide any required changes to the electrical service as may be necessary and related work as a part of the work for the section specifying that motor or equipment.

1.11.4 Modifications to Existing Systems

Where existing mechanical systems and motor-operated equipment require modifications, provide electrical components under Division 16.

1.11.5 High Efficiency Motors

1.11.5.1 High Efficiency Single-Phase Motors

Unless otherwise specified, single-phase fractional-horsepower alternating-current motors shall be high efficiency types corresponding to the applications listed in NEMA MG 11.

1.11.5.2 High Efficiency Polyphase Motors

Unless otherwise specified, polyphase motors shall be selected based on high efficiency characteristics relative to the applications as listed in NEMA MG 10. Additionally, polyphase squirrel-cage medium induction motors with continuous ratings shall meet or exceed energy efficient ratings in accordance with Table 12-10 of NEMA MG 1.

1.11.6 Three-Phase Motor Protection

Provide controllers for motors rated 1-hp and above with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and overvoltage. Provide protection for motors from immediate restart by a time adjustable restart relay.

1.12 INSTRUCTION TO GOVERNMENT PERSONNEL

Where specified in the technical sections, furnish the services of competent instructors to give full instruction to designated Government personnel in the adjustment, operation, and maintenance of the specified systems and equipment, including pertinent safety requirements as required. Instructors shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work. Instruction shall be given during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. The number of man-days (8 hours per day) of instruction furnished shall be as specified in the individual section. [When more than 4 man-days of instruction are specified, use approximately half of the time for classroom instruction. Use other time for instruction with equipment or system. When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instructions to acquaint the operating personnel with the changes or modifications.]

1.13 LOCKOUT REQUIREMENTS

Provide disconnecting means capable of being locked out for machines and other equipment to prevent unexpected startup or release of stored energy in accordance with 29 CFR 1910.147. Mechanical isolation of machines and other equipment shall be in accordance with requirements of Division 15, "Mechanical."

PART 2 PRODUCTS

Not used.

PART 3   EXECUTION

3.1   PAINTING OF EQUIPMENT

3.1.1   Factory Applied

Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA ICS 6 corrosion-resistance test[and the additional requirements specified in the technical sections].

3.1.2   Field Applied

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in [Section 09900N, "Paints and Coatings"] [the section specifying the associated electrical equipment].

3.2   NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.3   WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side, but space the signs a maximum of 9 meters apart.

3.4   CABLE TAG INSTALLATION

Install cable tags in each manhole, handhole, and vault as specified, including each splice. Install cable tags over the fireproofing, if any, and locate the tags so that they are clearly visible without disturbing any cabling or wiring in the manholes, handholes, and vaults.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 16 - ELECTRICAL

SECTION 16070

SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT

04/99

-- End of Section Table of Contents --

SECTION 16070

SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT
04/99

PART 1   GENERAL

1.1   REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

CORPS OF ENGINEERS, HUNTSVILLE ENGINEERING AND SUPPORT CENTER (CEHNC)

TI 809-04	(1998) Seismic Design for Buildings

UNDERWRITERS LABORATORIES (UL)

UL 1570	(1995; Rev thru Feb 1999) Fluorescent Lighting Fixtures
UL 1571	(1995; Rev thru Feb 1999) Incandescent Lighting Fixtures

1.2   SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:
*8

SD-02 Shop Drawings

Lighting Fixtures in Buildings; G, RE~~AE~~
Equipment Requirements; G, RE~~AE~~

Detail drawings along with catalog cuts, templates, and erection and installation details, as appropriate, for the items listed. Submittals shall be complete in detail; shall indicate thickness, type, grade, class of metal, and dimensions; and shall show construction details, reinforcement, anchorage, and installation with relation to the building construction.

SD-03 Product Data

Lighting Fixtures in Buildings; G, RE~~AE~~
Equipment Requirements; G, RE~~AE~~

Copies of the design calculations with the detail drawings. Calculations shall be stamped by a registered engineer and shall verify the capability of structural members to which bracing is attached for carrying the load from the brace.

Contractor Designed Bracing; G, RE~~AE~~

Copies of the Design Calculations with the Drawings. Calculations shall be approved, certified, stamped and signed by a Registered Professional Engineer. Calculations shall verify the capability of structural members to which bracing is attached for carrying the load from the brace.

1.3 SYSTEM DESCRIPTION

1.3.1 General Requirements

The requirements for seismic protection measures described in this section shall be applied to the electrical equipment and systems listed below. Structural requirements shall be in accordance with Section 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT.

1.3.2 Electrical Equipment

Electrical equipment shall include the following items to the extent required on the drawings or in other sections of these specifications:

Generator Transfer Switches	Variable Frequency Drives
Control Panels	Conduit Racks
Panelboards	Cable Tray
Light Fixtures	Dry Type Transformers
Motor Control Centers	UPS
Switchboards (Floor Mounted)	
Generator	
Switchgear	

1.3.3 Electrical Systems

The following electrical systems shall be installed as required on the drawings and other sections of these specifications and shall be seismically protected in accordance with this specification: Life Safety Systems.

1.3.4 Contractor Designed Bracing

The Contractor shall design and bracing in accordance with TI 809-04 and additional data furnished by the Contracting Officer. Resistance to lateral forces induced by earthquakes shall be accomplished without consideration of friction resulting from gravity loads. TI 809-04 uses parameters for the building, not for the equipment in the building; therefore, corresponding adjustments to the formulas shall be required. Loadings determined using TI 809-04 are based on strength design; therefore, the AISC LRFP specifications shall be used for the design.

1.3.5 Conduits Requiring No Special Seismic Restraints

Seismic restraints may be omitted from electrical conduit less than 64 mm trade size. All other interior conduit, shall be seismically protected as specified.

1.4 EQUIPMENT REQUIREMENTS

1.4.1 Rigidly Mounted Equipment

The following specific items of equipment: engine-generators, transformers, switchboards and switchgear, motor control centers, variable frequency drives to be furnished under this contract shall be constructed and assembled to withstand the seismic forces specified in TI 809-04, Chapter 10. Each item of rigid electrical equipment shall be entirely located and rigidly attached on one side only of a building expansion joint. Piping, electrical conduit, etc., which cross the expansion joint shall be provided with flexible joints that are capable of accommodating displacements equal to the full width of the joint in both orthogonal directions.

PART 2 PRODUCTS

2.1 LIGHTING FIXTURE SUPPORTS

Lighting fixtures and supports shall conform to UL 1570 or UL 1571 as applicable.

2.2 SWAY BRACING MATERIALS

Sway bracing materials (e.g. rods, plates, rope, angles, etc.) shall be as specified in Section 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT.

PART 3 EXECUTION

3.1 SWAY BRACES FOR CONDUIT

Conduit shall be braced as for an equivalent weight pipe in accordance with Section 15070 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT.

3.2 LIGHTING FIXTURES IN BUILDINGS

Lighting fixtures and supports shall conform to the following:

3.2.1 Pendant Fixtures

Pendant fixtures shall conform to the requirements of TI 809-04, Chapter 10.

3.2.2 Ceiling Attached Fixtures

3.2.2.1 Recessed Fluorescent Fixtures

Recessed fluorescent individual or continuous-row mounted fixtures shall be supported by a seismic-resistant suspended ceiling support system built in accordance with Section 09510 ACOUSTICAL CEILINGS. Seismic protection for the fixtures shall conform to the requirements of TI 809-04, Chapter 10. Recessed lighting fixtures not over 25 kg in weight may be supported by and attached directly to the ceiling system runners using screws or bolts, number and size as required by the seismic design. Fixture accessories, including louvers, diffusers, and lenses shall have lock or screw attachments.

3.2.2.2 Surface-Mounted Fluorescent Fixtures

Surface-mounted fluorescent individual or continuous-row fixtures shall be attached to a seismic-resistant ceiling support system built in accordance with Section 09510 ACOUSTICAL CEILINGS. Seismic protection for the fixtures shall conform to the requirements of TI 809-04, Chapter 10.

3.2.3 Assembly Mounted on Outlet Box

A supporting assembly, that is intended to be mounted on an outlet box, shall be designed to accommodate mounting features on 100 mm boxes, plaster rings, and fixture studs.

3.2.4 Lateral Force

Structural requirements for light fixture bracing shall be in accordance with Section 13080 SEISMIC PROTECTION FOR MISCELLANIOUS EQUIPMENT.

-- End of Section --

SECTION 16075

ELECTRICAL IDENTIFICATION

PART 1   GENERAL

1.1   REFERENCES

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1996) National Electrical Code

AMERICAN SOCIETY FOR TESTING AND MANUALS (ASTM)

ASTM C 1036-91	(Reapproved 1997) Specification for Flat Glass
ASTM D 709-92	(Reapproved 1997) Specification for Laminated Thermosetting Materials

1.4   SUBMITTALS

Government approval is required for submittals with a “G” designation; submittals not having a “G” designation are for information only. When usd, a designation following the “G” designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data:

Identification Product Literature: G, RE

For each electrical identification product indicatedz

Schedule of Nomenclature; G, RE

An index of electrical equipment and system components used in identification signs and labels.

Samples; G, RE

For each type of label and sign to illustrate color, lettering style, and graphic features of identification products.

1.5   COORDINATION

Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

Coordinate installation of identifying devices with location of access panels and doors.

Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2   PRODUCTS

2.1 RACEWAY AND CABLE LABELS

Comply with ANSI A13.1, Table 3, for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

Color: Black letters on orange field.

Legend: Indicates 480 volts.

Adhesive Labels: Preprinted, flexible, self-adhesive vinyl with legend overlaminated with a clear, weather- and chemical-resistant coating.

Pretensioned, Wraparound Plastic Sleeves: Flexible, preprinted, color-coded, acrylic band sized to suit the diameter of the line it identifies and arranged to stay in place by pretensioned gripping action when placed in position.

Colored Adhesive Tape: Self-adhesive vinyl tape not less than 0.08 mm thick by 25 to 51 mm wide.

Underground-Line Warning Tape: Permanent, bright-colored, continuous-printed, vinyl tape.

Not less than 152 mm wide by 0.102 mm thick.
Compounded for permanent direct-burial service.
Embedded continuous metallic strip or core.
Printed legend indicating type of underground line.

Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters.

Aluminum, Wraparound Marker Bands: Bands cut from 0.4-mm thick aluminum sheet, with stamped or embossed legend, and fitted with slots or ears for permanently securing around wire or cable jacket or around groups of conductors.

Plasticized Card-Stock Tags: Vinyl cloth with preprinted and field-printed legends. Orange background, unless otherwise indicated, with eye-let for fastener.

Aluminum-Faced, Card-Stock Tags: Weather-resistant, 18-point minimum card stock faced on both sides with embossable aluminum sheet, 0.05 mm thick, laminated with moisture-resistant acrylic adhesive, punched for fasteners, and preprinted with legends to suit each application.

Brass or Aluminum Tags: 51 by 51 by 1.3-mm metal tags with stamped legend, punched for fastener.

2.2 NAMEPLATES AND SIGNS

Safety Signs: Comply with 29 CFR, Chapter XVII, Part 1910.145.

Engraved Plastic Nameplates and Signs: Engraving stock, melamine plastic laminate, minimum 1.6 mm thick for signs up to 129 sq. cm and 3.2 mm thick for larger sizes.

Engraved legend with black letters on white face.

Punched or drilled for mechanical fasteners.

Baked-Enamel Signs for Interior Use: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for the application. 6.4-mm grommets in corners for mounting.

Exterior, Metal-Backed, Butyrate Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 1-mm galvanized-steel backing; and with colors, legend, and size required for the application. 6.4-mm grommets in corners for mounting.

Fasteners for Nameplates and Signs: Self-tapping, stainless-steel screws or No. 10/32, stainless-steel machine screws with nuts and flat and lock washers.

2.3 MISCELLANEOUS IDENTIFICATION PRODUCTS

Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.

Minimum Width: 5 mm.
Tensile Strength: 22.3 kg minimum.
Temperature Range: Minus 40 to plus 85 deg C.
Color: According to color-coding.

Paint: Formulated for the type of surface and intended use.

Primer for Galvanized Metal: Single-component acrylic vehicle formulated for galvanized surfaces.

Primer for Concrete Masonry Units: Heavy-duty-resin block filler.

Primer for Concrete: Clear, alkali-resistant, binder-type sealer.
Enamel: Silicone-alkyd or alkyd urethane as recommended by primer manufacturer.

PART 3 EXECUTION

3.1 INSTALLATION

Identification Materials and Devices: Install at locations for most convenient viewing without interference with operation and maintenance of equipment.

Lettering, Colors, and Graphics: Coordinate names, abbreviations, colors, and other designations with corresponding designations in the Contract Documents or with those required by codes and standards. Use consistent designations throughout Project.

Sequence of Work: If identification is applied to surfaces that require finish, install identification after completing finish work.

Self-Adhesive Identification Products: Clean surfaces before applying.

Circuits with More Than 600 V: Identify raceway and cable with "DANGER--HIGH VOLTAGE" in black letters 51 mm high, stenciled with paint at 3-m intervals over a continuous, painted orange background. Identify the following:

Entire floor area directly above conduits running beneath and within 305 mm of a basement or ground floor that is in contact with earth or is framed above unexcavated space.

Wall surfaces directly external to conduits concealed within wall. All accessible surfaces of concrete envelope around conduits in vertical shafts, exposed in the building, or concealed above suspended ceilings.

Entire surface of exposed conduits.

Install painted identification according to manufacturer's written instructions and as follows:

Clean surfaces of dust, loose material, and oily films before painting.

Prime surfaces using type of primer specified for surface.

Apply one intermediate and one finish coat of enamel.

Color Banding Raceways and Exposed Cables: Band exposed and accessible raceways of the systems listed below:

Bands: Pretensioned, wraparound plastic sleeves; colored adhesive tape; or a combination of both. Make each color band 51 mm wide, completely encircling conduit, and place adjacent bands of two-color markings in contact, side by side.

Band Locations: At changes in direction, at penetrations of walls and floors, at 15-m maximum intervals in straight runs, and at 7.6-m maximum intervals in congested areas.

Apply the following colors to the systems listed below:

Security System: Blue and yellow.
Mechanical and Electrical Supervisory System: Green and blue.
Telecommunication System: Green and yellow.

Caution Labels for Indoor Boxes and Enclosures for Power and Lighting: Install pressure-sensitive, self-adhesive labels identifying system voltage with black letters on orange background. Install on exterior of door or cover.

Circuit Identification Labels on Boxes: Install labels externally.

Exposed Boxes: Pressure-sensitive, self-adhesive plastic label on cover.

Concealed Boxes: Plasticized card-stock tags.

Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent.

Paths of Underground Electrical Lines: During trench backfilling, for exterior underground power, control, signal, and communication lines, install continuous underground plastic line marker located directly above line at 150 to 200 mm below finished grade. Where width of multiple lines installed in a common trench or concrete envelope does not exceed 400 mm overall, use a single line marker. Install line marker for underground wiring, both direct-buried cables and cables in raceway].

Color-Coding of Secondary Phase Conductors: Use the following colors for feeder and branch-circuit phase conductors:

208/120-V Conductors:

Phase A: Black.
Phase B: Red.
Phase C: Blue.

480/277-V Conductors:

Phase A: Yellow.
Phase B: Brown.
Phase C: Orange.

Factory apply color the entire length of conductors, except the following field-applied, color-coding methods may be used instead of factory-coded wire for sizes larger than No. 10 AWG:

Colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 150 mm from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Use 25-mm wide tape in colors specified. Adjust tape bands to avoid obscuring cable identification markings.

Colored cable ties applied in groups of three ties of specified color to each wire at each terminal or splice point starting 76 mm from the terminal and spaced 76 mm apart. Apply with a special tool or pliers, tighten to a snug fit, and cut off excess length.

Power-Circuit Identification: Metal tags or aluminum, wraparound marker bands for cables, feeders, and power circuits in vaults, pull and junction boxes, manholes, and switchboard rooms.

Legend: 6.4-mm steel letter and number stamping or embossing with legend corresponding to indicated circuit designations.
Tag Fasteners: Nylon cable ties.
Band Fasteners: Integral ears.

Apply identification to conductors as follows:

Conductors to Be Extended in the Future: Indicate source and circuit numbers.

Multiple Power or Lighting Circuits in the Same Enclosure: Identify each conductor with source, voltage, circuit number, and phase. Use color-coding to identify circuits' voltage and phase.

Multiple Control and Communication Circuits in the Same Enclosure: Identify each conductor by its system and circuit designation. Use a consistent system of tags, color-coding, or cable marking tape.

Apply warning, caution, and instruction signs as follows:

Warnings, Cautions, and Instructions: Install to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.

Emergency Operation: Install engraved laminated signs with white legend on red background with minimum 9-mm high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.

Equipment Identification Labels: Engraved plastic laminate. Install on each unit of equipment, including central or master unit of each system. This includes power, lighting, communication, signal, and alarm systems, unless units are specified with their own self-explanatory identification. Unless otherwise indicated, provide a single line of text with 13-mm high lettering on 38-mm high label; where two lines of text are required, use labels 50 mm high. Use white lettering on black field. Apply labels for each unit of the following categories of equipment using mechanical fasteners:

Panelboards, electrical cabinets, and enclosures.
Access doors and panels for concealed electrical items.
Electrical switchgear and switchboards.
Emergency system boxes and enclosures.
Motor-control centers.
Disconnect switches.
Enclosed circuit breakers.
Motor starters.
Push-button stations.
Power transfer equipment.
Contactors.
Remote-controlled switches.
Control devices.
Transformers.
Battery racks.
Power-generating units.
Telephone switching equipment.
Security-monitoring master station or control panel.

END OF SECTION 16075

SECTION TABLE OF CONTENTS

DIVISION 16 - ELECTRICAL

SECTION 16261

VARIABLE FREQUENCY DRIVE SYSTEMS UNDER 600 VOLTS

09/99

-- End of Section Table of Contents --

SECTION 16261

VARIABLE FREQUENCY DRIVE SYSTEMS UNDER 600 VOLTS
09/99

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

CODE OF FEDERAL REGULATIONS (CFR)

47 CFR 15	Radio Frequency Devices

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC. (IEEE)

IEEE 519	(1992) Harmonic Control in Electrical Power Systems
IEEE C62.41	(1991) Surge Voltages in Low-Voltage AC Power Circuits

MILITARY STANDARDS (MIL-STD)

MIL-STD-461	(Rev. D) Control of Electromagnetic Interference Emissions and Susceptibility

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(1991) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(1993) Industrial Control and Systems
NEMA ICS 3.1	(1990) Construction and Guide for Selection, Installation and Operation of Adjustable-Speed Drive Systems
NEMA ICS 6	(1993) Industrial Control and Systems Enclosures
NEMA ICS 7	(1993) Industrial Control and Systems Adjustable-Speed Drives

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1999) National Electrical Code

UNDERWRITERS LABORATORIES INC. (UL)

UL 489	(1996; R 1998) Molded-Case Circuit Breakers and Circuit-Breaker Enclosures
UL 508C	(1996) Power Conversion Equipment

1.2 RELATED REQUIREMENTS

Section 16050, "Basic Electrical Materials and Methods", and Section 16402, "Distribution Wiring System" apply to this section with additions and modifications specified herein.

1.3 SYSTEM DESCRIPTION

1.3.1 Performance Requirements

1.3.1.1 Electromagnetic Interference Suppression

Computing devices, as defined by 47 CFR 15, MIL-STD-461 rules and regulations, shall be certified to comply with the requirements for class A computing devices and labeled as set forth in part 15.

1.3.1.2 Electromechanical and Electrical Components

Electrical and electromechanical components of the Variable Frequency Drive (VFD) shall not cause electromagnetic interference to adjacent electrical or electromechanical equipment while in operation.

1.3.2 Electrical Requirements

1.3.2.1 Power Line Surge Protection

IEEE C62.41, IEEE 519 Control panel shall have surge protection, included within the panel to protect the unit from damaging transient voltage surges. Surge arrestor shall be mounted near the incoming power source and properly wired to all three phases and ground. Fuses shall not be used for surge protection.

1.3.2.2 Sensor and Control Wiring Surge Protection

I/O functions as specified shall be protected against surges induced on control and sensor wiring installed outdoors and as shown. The inputs and outputs shall be tested in both normal mode and common mode using the following two waveforms:

a. A 10 microsecond by 1000 microsecond waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.

b. An 8 microsecond by 20 microsecond waveform with a peak voltage of 1000 volts and a peak current of 500 amperes.

1.4 SUBMITTALS

Submit the following in accordance with Section 01330, "Submittal Procedures."

*8

SD-02 Shop Drawings

Schematic diagrams; G, RE~~AE~~

Interconnecting diagrams; G, RE~~AE~~

Installation drawings; G, RE~~AE~~

Submit drawings for government approval prior to equipment construction or integration. Modifications to original drawings made during installation shall be immediately recorded for inclusion into the as-built drawings.

SD-03 Product Data

Variable frequency drives; G, RE~~AE~~

Wires and cables; G, RE~~AE~~

Equipment schedule; G, RE~~AE~~

Include data indicating compatibility with motors being driven.

SD-06 Test Reports

VFD Test; G, RE

Performance Verification Tests; G, RE

Endurance Test; G, RE

SD-08 Manufacturer's Instructions

Installation instructions; G, RE

SD-09 Manufacturer's Field Reports

VFD Factory Test Plan; G, RE

Factory test results; G, RE

SD-10 Operation and Maintenance Data

Variable frequency drives, Data Package 4; G, RE~~AE~~

"Operation and Maintenance Data" shall provide service and maintenance information including preventive maintenance, assembly, and disassembly procedures. Include electrical drawings from electrical general sections. Submit additional information necessary to provide complete operation, repair, and maintenance information, detailed to the smallest replaceable unit. Include copies of as-built submittals. Provide routine preventative maintenance instructions, and equipment required. Provide instructions on how to modify program settings, and modify the control program. Provide instructions on drive adjustment, trouble-shooting, and configuration. Provide instructions on process tuning and system calibration.

1.5 QUALITY ASSURANCE

1.5.1 Schematic Diagrams

Show circuits and device elements for each replaceable module. Schematic diagrams of printed circuit boards are permitted to group functional assemblies as devices, provided that sufficient information is provided for government maintenance personnel to verify proper operation of the functional assemblies.

1.5.2 Interconnecting Diagrams

Show interconnections between equipment assemblies, and external interfaces, including power and signal conductors. Include for enclosures and external devices.

1.5.3 Installation Drawings

Show floor plan of each site, with V.F.D.'s and motors indicated. Indicate ventilation requirements, adequate clearances, and cable routes.

1.5.4 Equipment Schedule

Provide schedule of equipment supplied. Schedule shall provide a cross reference between manufacturer data and identifiers indicated in shop drawings. Schedule shall include the total quantity of each item of equipment supplied. For complete assemblies, such as VFD's, provide the serial numbers of each assembly, and a sub-schedule of components within the assembly. Provide recommended spare parts listing for each assembly or component.

1.5.5 Installation instructions

Provide installation instructions issued by the manufacturer of the equipment, including notes and recommendations, prior to shipment to the site. Provide operation instructions prior to acceptance testing.

1.5.6 Factory Test Results

Document test results and submit to government within 7 working days after completion of test.

1.6 DELIVERY AND STORAGE

Equipment delivered and placed in storage shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

1.7 WARRANTY

The complete system shall be warranted by the manufacturer for a period of one year, or the contracted period of any extended warrantee agreed upon by the contractor and the Government, after successful completion of the acceptance test. Any component failing to perform its function as specified and documented shall be repaired or replaced by the contractor at no additional cost to the Government. Items repaired or replaced shall be warranted for an additional period of at least one year from the date that it becomes functional again, as specified in the FAR CLAUSE 52.246-21.

1.8 MAINTENANCE

1.8.1 Spare Parts

A complete list of spare parts for each piece of equipment and a complete list of all material and supplies needed for continued operation. Lists shall include supply source and current prices. Each list shall be separated into two parts, those elements recommended by the manufacture to be replaced after 3 years of service, and the remaining elements.

1.8.2 Maintenance Support

During the warranty period, the Contractor shall provide on-site, on-call maintenance services by Contractor's personnel on the following basis: The service shall be on a per-call basis with 36 hour response. Contractor shall support the maintenance of all hardware and software of the system. Various personnel of different expertise shall be sent on-site depending on the nature of the maintenance service required. Costs shall include travel, local transportation, living expenses, and labor rates of the service personnel while responding to the service request. The provisions of this Section are not in lieu of, nor relieve the Contractor of, warranty responsibilities covered in this specification. Should the result of the service request be the uncovering of a system defect covered under the warranty provisions, all costs for the call, including the labor necessary to identify the defect, shall be borne by the Contractor.

PART 2 PRODUCTS

2.1 VARIABLE FREQUENCY DRIVES (VFD)

Provide frequency drive to control the speed of induction motor(s). The VFD shall include the following minimum functions, features and ratings.

a. Input circuit breaker per UL 489 with a minimum of 65,000 amps symmetrical interrupting capacity and door interlocked external operator.

b. A converter stage per UL 508C shall change fixed voltage, fixed frequency, ac line power to a fixed dc voltage. The converter shall utilize a full wave bridge design incorporating diode rectifiers. Silicon Controlled Rectifiers (SCR) are not acceptable. The converter shall be insensitive to three phase rotation of the ac line and shall not cause displacement power factor of less than .95 lagging under any speed and load condition.

c. An inverter stage shall change fixed dc voltage to variable frequency, variable voltage, ac for application to a standard NEMA design B squirrel cage motor. The inverter shall be switched in a manner to produce a sine coded pulse width modulated (PWM) output waveform.

d. The VFD shall be capable of supplying 120 percent of rated full load current for one minute at maximum ambient temperature.

e. The VFD shall be designed to operate from a 480 volt, + or - 10 percent, three phase, 60 Hz supply, and control motors with a corresponding voltage rating.

f. Acceleration and deceleration time shall be independently adjustable from one second to 60 seconds.

g. Adjustable full-time current limiting shall limit the current to a preset value which shall not exceed 120 percent of the controller rated current. The current limiting action shall maintain the V/Hz ratio constant so that variable torque can be maintained. Short time starting override shall allow starting current to reach 175 percent of controller rated current to maximum starting torque.

h. The controllers shall be capable of producing an output frequency over the range of 3 Hz to 60 Hz (20 to one speed range), without low speed cogging. Over frequency protection shall be included such that a failure in the controller electronic circuitry shall not cause frequency to exceed 110 percent of the maximum controller output frequency selected.

i. Minimum and maximum output frequency shall be adjustable over the following ranges: 1) Minimum frequency 3 Hz to 50 percent of maximum selected frequency; 2) Maximum frequency 40 Hz to 60 Hz.

j. The controller efficiency at any speed shall not be less than 96 percent.

k. The controllers shall be capable of being restarted into a motor coasting in the forward direction without tripping.

l. Protection of power semiconductor components shall be accomplished without the use of fast acting semiconductor output fuses. Subjecting the controllers to any of the following conditions shall not result in component failure or the need for fuse replacment:

1. Short circuit at controller output

2. Ground fault at controller output

3. Open circuit at controller output

4. Input undervoltage

5. Input overvoltage

6. Loss of input phase

7. AC line switching transients

8. Instantaneous overload

9. Sustained overload exceeding 115 percent of controller rated current

10. Over temperature

11. Phase reversal

m. Solid state motor overload protection shall be included such that current exceeding an adjustable threshold shall activate a 60 second timing circuit. Should current remain above the threshold continuously for the timing period, the controller will automatically shut down.

n. A slip compensation circuit shall be included which will sense changing motor load conditions and adjust output frequency to provide speed regulation of NEMA B motors to within + / - 0.5 percent of maximum speed without the necessity of a tachometer generator.

o. The VFD shall be factory set for manual restart after the first protective circuit trip for malfunction (overcurrent,undervoltage, overvoltage or overtemperature) or an interruption of power. The VFD shall be capable of being set for automatic restart after a selected time delay. If the drive faults again within a specified time period (adjustable 0-60 seconds), a manual restart will be required.

p. The VFD shall include external fault reset capability. All the necessary logic to accept an external fault reset contact shall be included.

q. Provide critical speed lockout circuitry to prevent operating at frequencies with critical harmonics that cause resonant vibrations. The VFD shall have a minimum of three user selectable bandwidths.

r. Provide the following operator control and monitoring devices mounted on the front panel of the VFD:

1. Manual speed potentiometer.
2. Hand-Off-Auto (HOA) switch.
3. Power on light.
4. Drive run power light.
5. Local display.

s. Provide properly sized NEMA rated by-pass and isolation contactors to enable operation of motor in the event of VFD failure. Mechanical and electrical interlocks shall be installed between the by-pass and isolation contactors. Provide a selector switch and transfer delay timer.

t. Three phase, AC input line reactors shall be provided as a minimum, with all VFDs. The line reactors are to provide attenuation of line side voltage transients and shall meet the following requirements.

1. Minimum of 2-1/2 percent line impedance
2. 150 percent continuous current rating for one minute
3. Saturation ratings
4. UL recognized
5. Dry type
6. Copper windings and Class H (185 degree C rise) insulation.

7. The VFD shall include an output DV/DT filter or reactor to limit voltage spikes at the motor, where motors are located in excess of 100 feet of source. The filter on the reactor shall be housed in the VFD enclosures.

2.2 ENCLOSURES

Provide equipment enclosures conforming to NEMA 250, NEMA ICS 7, NEMA ICS 6.

2.3 WIRES AND CABLES

All wires and cables shall conform to NEMA 250, NEMA ICS 7, NFPA 70.

2.4 NAMEPLATES

Nameplates external to NEMA enclosures shall conform with the requirements of Section 16050, "Basic Electrical Materials and Methods." Nameplates internal to enclosures shall be manufacturer's standard, with the exception that they must be permanent.

2.5 SOURCE QUALITY CONTROL

2.5.1 VFD Factory Test Plan

To ensure quality, each VFD shall be subject to a series of in-plant quality control inspections before approval for shipment from the manufacturer's facilities. Provide test plans and test reports.

PART 3 EXECUTION

3.1 INSTALLATION

Per NEMA ICS 3.1, install equipment in accordance with the approved manufacturer's printed installation drawings, instructions, wiring diagrams, and as indicated on project drawings and the approved shop drawings. A field representative of the drive manufacturer shall supervise the installation of all equipment, and wiring.

3.2 FIELD QUALITY CONTROL

Specified products shall be tested as a system for conformance to specification requirements prior to scheduling the acceptance tests. Contractor shall conduct performance verification tests in the presence of Government representative, observing and documenting complete compliance of the system to the specifications. Contractor shall submit a signed copy of the test results, certifying proper system operation before scheduling tests.

3.2.1 VFD Test

A proposed test plan shall be submitted to the contracting officer at least 28 calendar days prior to proposed testing for approval. The tests shall conform to NEMA ICS 1, NEMA ICS 7, and all manufacturer's safety regulations. The Government reserves the right to witness all tests and review any documentation. The contractor shall inform the Government at least 14 working days prior to the dates of testing. Contractor shall provide video tapes, if available, of all training provided to the Government for subsequent use in training new personnel. All training aids, texts, and expendable support material for a self-sufficient presentation shall be provided, the amount of which to be determined by the contracting officer.

3.2.2 Performance Verification Tests

"Performance Verification Test" plan shall provide the step by step procedure required to establish formal verification of the performance of the VFD. Compliance with the specification requirements shall be verified by inspections, review of critical data, demonstrations, and tests. The Government reserves the right to witness all tests, review data, and request other such additional inspections and repeat tests as necessary to ensure that the system and provided services conform to the stated requirements. The contractor shall inform the Government 14 calendar days prior to the date the test is to be conducted.

3.2.3 Endurance Test

Immediately upon completion of the performance verification test, the endurance test shall commence. The system shall be operated at varying rates for not less than 192 consecutive hours, at an average effectiveness level of .9998, to demonstrate proper functioning of the complete PCS. Continue the test on a day-to-day basis until performance standard is met. During the endurance test, the contractor shall not be allowed in the building. The system shall respond as designed.

3.3 DEMONSTRATION

3.3.1 Training

Coordinate training requirements with the Contracting Officer.

3.3.1.1 Instructions to Government Personnel

Provide the services of competent instructors who will give full instruction to designated personnel in operation, maintenance, calibration, configuration, and programming of the complete control system. Orient the training specifically to the system installed. Instructors shall be thoroughly familiar with the subject matter they are to teach. The Government personnel designated to attend the training will have a high school education or equivalent. The number of training days of instruction furnished shall be as specified. A training day is defined as eight hours of instruction, including two 15-minute breaks and excluding lunch time; Monday through Friday. Provide a training manual for each student at each training phase which describes in detail the material included in each training program. Provide one additional copy for archiving. Provide equipment and materials required for classroom training. Provide a list of additional related courses, and offers, noting any courses recommended. List each training course individually by name, including duration, approximate cost per person, and location of course. Unused copies of training manuals shall be turned over to the Government at the end of last training session.

3.3.1.2 Operating Personnel Training Program

Provide one 2 hour training session at the site at a time and place mutually agreeable between the Contractor and the Government. Provide session to train 4 operation personnel in the functional operations of the system and the procedures that personnel will follow in system operation. This training shall include:

a. System overview

b. General theory of operation

c. System operation

d. Alarm formats

e. Failure recovery procedures

f. Troubleshooting

3.3.1.3 Engineering/Maintenance Personnel Training

Accomplish the training program as specified. Training shall be conducted on site at a location designated by the Government. Provide a one day training session to train 4 engineering personnel in the functional operations of the system. This training shall include:

a. System overview

b. General theory of operation

c. System operation

d. System configuration

e. Alarm formats

f. Failure recovery procedures

g. Troubleshooting and repair

h. Maintenance and calibration

i. System programming and configuration

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 16 - ELECTRICAL

SECTION 16263A

DIESEL-GENERATOR SET STATIONARY 1500 KW, WITH AUXILIARIES

04/99

-- End of Section Table of Contents --

SECTION 16263A

DIESEL-GENERATOR SET STATIONARY 1500 KW, WITH AUXILIARIES
04/99

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS5	(1994; CS5a-1995) Cross-Linked Polyethylene Insulated Shielded Power Cables Rated 5 Through 46 kV
AEIC CS6	(1996) Ethylene Propylene Rubber Insulated Shielded Power Cables Rated 5 Through 69 kV

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.11	(1987; R 1993) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)
ANSI C39.1	(1981; R 1992) Requirements for Electrical Analog Indicating Instruments

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 53	(1998) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 106	(1997a) Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A 181/A 181M	(1995b) Carbon Steel Forgings for General-Purpose Piping
ASTM A 234/A 234M	(1997) Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperatures
ASTM B 395	(1995) U-Bend Seamless Copper and Copper Alloy Heat Exchanger and Condenser Tubes
ASTM B 395M	U-Beam Seamless Copper and Copper Alloy Heat Exchanger and Condenser Tubes (Metric)
ASTM D 975	(1997) Diesel Fuel Oils

ASME INTERNATIONAL (ASME)

ASME B16.3	(1992) Malleable Iron Threaded Fittings
ASME B16.5	(1996; B16.5a) Pipe Flanges and Flanged Fittings NPS 1/2 thru NPS 24
ASME B16.11	(1996) Forged Fittings, Socket-Welding and Threaded
ASME B31.1	(1998) Power Piping
ASME BPV VIII Div 1	(1998) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage
ASME BPV IX	(1998) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications

ELECTRICAL GENERATING SYSTEMS ASSOCIATION (EGSA)

EGSA 101P	(1995a) Engine Driven Generator Sets

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(1997) National Electrical Safety Code
IEEE C57.13	(1993) Instrument Transformers
IEEE ANSI/IEEE C57.13.1	(1981; R 1992) IEEE Guide for Field Testing of Relaying Current Transformers
IEEE Std 1	(1986; R 1992) General Principles for Temperature Limits in the Rating of Electric Equipment and for the Evaluation of Electrical Insulation
IEEE Std 43	(1974; R 1991) Testing Insulation Resistance of Rotating Machinery
IEEE Std 48	(1998) Standard Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5 kV through 765 kV
IEEE Std 81	(1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1)
IEEE Std 100	(1996) IEEE Standard Dictionary of Electrical and Electronics Terms
IEEE Std 120	(1989) Electrical Measurements in Power Circuits
IEEE Std 115	(1995) Test Procedures for Synchronous Machines
IEEE Std 404	(1993; errata) Cable Joints for Use with Extruded Dielectric Cable Rated 5000 V

	Through 138 000 V and Cable Joints for Use with Laminated Dielectric Cable Rated 2500 V Through 500 000 V
IEEE Std 484	(1996) Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications
IEEE Std 485	(1997) Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations
IEEE Std 519	(1992) Harmonic Control in Electrical Power systems

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(1993) Pipe Hangers and Supports - Materials, Design and Manufacture
MSS SP-69	(1996) Pipe Hangers and Supports - Selection and Application
MSS SP-80	(1997) Bronze Gate, Globe, Angle and Check Valves

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 2	(1993) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated Not More Than 2,000 Volts AC or 750 Volts DC
NEMA ICS 6	(1993) Industrial Control and Systems, Enclosures
NEMA MG 1	(1993; Rev 1; Rev 2; Rev 3 Rev 4) Motors and Generators
NEMA PB 1	(1995) Panelboards
NEMA PB 2	(1995) Deadfront Distribution Switchboards
NEMA SG 5	(1995) Power Switchgear Assemblies
NEMA WC 7	(1991; Rev 1) Cross-Linked-thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy
NEMA WC 8	(1991; Rev 1; Rev 2) Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 30 (1996; Errata; TIA 96-2) Flammable and Combustible Liquids Code

NFPA 37 (1998) Installation and Use of Stationary Combustion Engines and Gas Turbines

NFPA 70 (1999) National Electrical Code

NFPA 99 (1999) Health Care Facilities

NFPA 110 (1999) Emergency and Standby Power Systems

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

SAE J 537 (1996) Storage Batteries

UNDERWRITERS LABORATORIES (UL)

UL 891 (1994; Rev thru Jan 1995) Dead-Front Switchboards

UL 1236 (1994; Rev thru Dec 1997) Battery Chargers for Charging Engine-Starter Batteries

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

*8

SD-02 Shop Drawings

Layout; G, RE~~AE~~
General Installation; G, RE~~AE~~

Drawings shall include the following:

a. Base-mounted equipment, complete with base, fuel tank and attachments, including anchor bolt template and recommended clearances for maintenance and operation.

b. Complete starting system.

c. Complete fuel system.

d. Complete cooling system.

e. Complete exhaust system.

f. Layout of relays, breakers, programmable controllers,switchgear, and switches including applicable single line and wiring diagrams with written description of sequence of operation and the instrumentation provided.

g. The complete lubrication system, including piping, pumps, strainers, filters, heat exchangers for lube oil and turbocharger cooling, electric heater, controls and wiring.

h. Location, type, and description of vibration isolation devices for all applications.

i. The safety system, together with a detailed description of how it is to work. Wiring schematics, safety devices with a listing of their normal ranges, alarm and shutdown values (to include operation parameters such as pressures, temperatures voltages, currents, and speeds) shall be included.

j. One-line schematic and wiring diagrams of the generator, exciter, regulator, governor, and instrumentation.

k. Layout of each panel.

l. Mounting and support for each panel and major piece of electrical equipment.

m. Engine-generator set lifting points and rigging instructions.

Acceptance; G, RE~~AE~~

Drawings which accurately depict the as-built configuration of the installation, upon acceptance of the diesel-generator set installation. Layout drawings shall be revised to reflect the as-built conditions and shall be submitted with the as-built drawings.

SD-03 Product Data

Performance Criteria; G, RE~~AE~~

Calculations of the engine and generator output power capability, including efficiency and parasitic load data.

Sound Limitations; G, RE~~AE~~

Sound power level data for the packaged unit operating at 100% load in a free field environment. The data should demonstrate compliance with the sound limitation requirements of this specification.

Harmonic Requiremants; G, RE~~AE~~
Engine-Generator Parameter Schedule; G, RE~~AE~~

Description of the generator features which mitigate the effects of the non-linear loads listed.

Integral Main Fuel Storage Tank; G, RE~~AE~~
Day Tank; G, RE~~AE~~

Calculations for the capacity of each day tank, including allowances for recirculated fuel, usable tank capacity, and duration of fuel supply.

Power Factor; G, RE~~AE~~

The generator capability curve showing generator kVA output capability (kW vs. kvar) for both leading and lagging power factors ranging from 0 to 1.0.

Heat Rejected To Engine-Generator Space; G, RE~~AE~~

Manufacturers data to quantify heat rejected to the space with the engine generator set at rated capacity.

Cooling System; G, RE~~AE~~

A letter which certifies that the engine-generator set and cooling system function properly in the ambient temperature specified.

a. The maximum allowable inlet temperature of the coolant fluid.

b. The minimum allowable inlet temperature of the coolant fluid.

c. The maximum allowable temperature rise in the coolant fluid through the engine.

Time-Delay on Alarms; G, RE~~AE~~

The magnitude of monitored values which define alarm or action set points, and the tolerance (plus and/or minus) at which the devices activate the alarm or action for items contained within the alarm panels.

Generator; G, RE~~AE~~

Manufacturer's standard data for each generator (prototype data at the specified rating or above is acceptable), listing the following information:

Direct-Axis subtransient reactance (per unit).

The generator kW rating and short circuit current capacity (both symmetric and asymmetric)

Manufacturer's Catalog; G, RE~~AE~~

Manufacturer's standard catalog data describing and depicting each engine-generator set and all ancillary equipment in sufficient detail to demonstrate complete specification compliance.

Site Welding; G, RE

A copy of qualifying procedures and a list of names and identification symbols of qualified welders and welding operators.

A letter listing the welder qualifying procedures for each welder, complete with supporting data such as test procedures used, what was tested to, and a list of the names of all welders and their identification symbols.

Spare Parts; G, RE

A complete list of spare parts for each piece of equipment and a complete list of all material and supplies needed for continued operation. Lists shall include supply source and current prices.

Each list shall be separated into two parts, those elements recommended by the manufacturer to be replaced after 3 years of service, and the remaining elements.

Onsite Training; G, RE

A letter giving the date proposed for conducting the onsite training course, the agenda of instruction, a description of the video taping service to be provided, and the kind and quality of the tape to be left with the Contracting Officer at the end of the instructional period.

Battery Charger; G, RE~~AE~~

Battery charger sizing calculations.

Vibration-Isolation; G, RE~~AE~~

Vibration isolation system performance data for the range of frequencies generated by the engine-generator set during operation from no load to full load and the maximum vibration transmitted to the floor. Description of seismic qualification of the engine-generator mounting, base, and vibration isolation.

Posted Data and Instructions; G, RE~~AE~~

Posted data including wiring and control diagrams showing the key mechanical and electrical control elements, and a complete layout of the entire system.

Instructions; G, RE

Instructions including: the manufacturers pre-start checklist and precautions; startup procedures for test-mode, manual-start mode, and automatic-start mode (as applicable); running checks, procedures, and precautions; and shutdown procedures, checks, and precautions. Instructions shall include procedures for interrelated equipment (such as automatic transfer switches). Instructions shall be weatherproof, laminated in plastic, and posted where directed.

Experience; G, RE~~AE~~

Each component manufacturer has a minimum of 3 years experience in the manufacture, assembly and sale of components used with stationary diesel engine-generator sets for commercial and industrial use. The engine-generator set manufacturer/assembler has a minimum of 3 years experience in the manufacture, assembly and sale of stationary diesel engine-generator sets for commercial and industrial use.

Field Engineer; G, RE

A letter listing the qualifications, schools, formal training, and experience of the field engineer.

General Installation; G, RE

A copy of the manufacturer's installation procedures and a detailed description of the manufacturer's recommended break-in procedure.

SD-06 Test Reports

Factory Inspection and Tests; G, RE

Six complete reproducible copies of the factory inspection result on the checklist format specified in paragraph FACTORY INSPECTION AND TESTS.

Factory Tests; G, RE

a. A letter giving notice of the proposed dates of factory inspections and tests at least 14 days prior to beginning tests.

b. A detailed description of the manufacturer's procedures for factory tests at least 14 days prior to beginning tests.

c. Six copies of the Factory Test data described below in 215.9 x 279.4 mm binders having a minimum of 3 rings from which material may readily be removed and replaced, including a separate section for each test. Sections shall be separated by heavy plastic dividers with tabs. Data plots shall be full size (215.9 x 279.4 mm minimum), showing grid lines, with full resolution.

(1) A detailed description of the procedures for factory tests.

(2) A list of equipment used, with calibration certifications.

(3) A copy of measurements taken, with required plots and graphs.

(4) The date of testing.

(5) A list of the parameters verified.

(6) The condition specified for the parameter.

(7) The test results, signed and dated.

(8) A description of adjustments made.

Onsite Inspection and Tests; G, RE

a. A letter giving notice of the proposed dates of onsite inspections and tests at least 14 days prior to beginning tests.

b. A detailed description of the Contractor's procedures for onsite tests including the test plan and a listing of equipment necessary to perform the tests. Submission shall be at least 14 days prior to beginning tests.

c. Six copies of the onsite test data described below in 215.9 x 279.4 mm binders having a minimum of 3 rings from which material may readily be removed and replaced, including a separate section for each test. Sections shall be separated by heavy plastic dividers with tabs. Data plots shall be full size (215.9

x 279.4 mm minimum), showing grid lines, with full resolution.

(1) A detailed description of the procedures for onsite tests.

(2) A list of equipment used, with calibration certifications.

(3) A copy of measurements taken, with required plots and graphs.

(4) The date of testing.

(5) A list of the parameters verified.

(6) The condition specified for the parameter.

(7) The test results, signed and dated.

(8) A description of adjustments made.

SD-07 Certificates

Vibration Isolation; G, RE

Torsional analysis including prototype testing or and calculations which certify and demonstrate that no damaging or dangerous torsional vibrations will occur when the prime mover is connected to the generator, at synchronous speeds, $\pm$ 10%.

Prototype Test; G, RE

Manufacturer's standard certification that prototype tests were performed for the generator model proposed.

Reliability and Durability; G, RE

A reliability and durability certification letter from the manufacturer and assembler to prove that existing facilities are and have been successfully utilizing the same components proposed to meet this specification, in similar service. Certification may be based on components, i.e. engines used with different models of generators and generators used with different engines, and does not exclude annual technological improvements made by a manufacturer in the basic standard-model component on which experience was obtained, provided parts interchangeability has not been substantially affected and the current standard model meets the performance requirements specified. Provide a list with the name of the installations, completion dates, and name and telephone number of a point of contact.

Emissions; G, RE

A certification from the engine manufacturer stating that the engine exhaust emissions meet the federal, state, and local regulations and restrictions specified. At a minimum this certification shall include emission factors for criteria pollutants including nitrogen oxides, carbon monoxide, particulate matter, sulfur dioxide, non-methane hydrocarbon, and for hazardous air pollutants (HPAs).

Sound Limitations; G, RE

A certification from the manufacturer stating that the sound emissions meet the specification.

Site Visit; G, RE

A letter stating the date the site was visited and listing discrepancies found.

Flywheel Balance; G, RE

A certification stating that the flywheel has been statically and dynamically balanced and is capable of being rotated at 125% of rated speed without vibration or damage.

Materials and Equipment; G, RE

A certification stating that where materials or equipment are specified to comply with requirements of UL, written proof of such compliance has been obtained. The label or listing of the specified agency, or a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency are acceptable as proof.

Inspections; G, RE

A letter certifying that all facilities are complete and functional; that each system is fully functional; and that each item of equipment is complete, free from damage, adjusted, and ready for beneficial use.

Cooling System; G, RE

Certification that the engine-generator set and cooling system function properly in the ambient temperatures specified.

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G, RE

Six copies of the operation manual (approved prior to commencing onsite tests) in 215.9 x 279.4 mm binders, having a minimum of 3 rings from which material may readily be removed and replaced, including a separate section for each system or subsystem. Sections shall be separated by heavy plastic dividers with tabs which identify the material in the section. Drawings shall be folded blue lines, with the title block visible, and placed in 215.9 x 279.4 mm plastic pockets with reinforced holes. One full size reproducible mylar of each drawing shall accompany the booklets. Mylars shall be rolled and placed in a heavy cardboard tube with threaded caps on each end. The manual shall include: step-by-step procedures for system startup, operation, and shutdown; drawings, diagrams, and single-line schematics to illustrate and define the electrical, mechanical, and hydraulic systems together with their controls, alarms, and safety systems; the manufacturer's name, model number, and a description of equipment in the system. The instructions shall include procedures for interface and interaction with related systems to include automatic transfer switches fire alarm/suppression systems load shedding systems uninterruptible power supplies. Each booklet shall include a CDROM containing an ASCII file of the procedures.

Maintenance Procedures; G, RE

Six copies of the maintenance manual containing the information described below in 215.9 x 279.4 mm binders having a minimum of three rings from which material may readily be removed and replaced, including a separate section for each item listed. Each section shall be separated by a heavy plastic divider with tabs. Drawings shall be folded, with the title block visible, and placed in plastic pockets with reinforced holes.

a. Procedures for each routine maintenance item.

Factory-service, take-down overhaul, and repair service manuals, with parts lists.

b. A copy of the posted instructions.

c. A component list which includes the manufacturer's name, address, type or style, model or serial number, rating, and catalog number for the major components specified for nameplates.

Six complete reproducible copies of the final relay and protective device settings. The settings shall be recorded with the name of the company and individual responsible for their accuracy.

Special Tools; G, RE

Two complete sets of special tools required for maintenance (except for electronic governor handset). Special tools are those that only the manufacturer provides, for special purposes, or to reach otherwise inaccessible parts. The tools shall be supplied complete with a suitable tool box. One handset shall be provided for each electronic governor when required to indicate and/or change governor response settings.

Filters; G, RE

Two complete sets of filters, required for maintenance, shall be supplied in a suitable storage box. These filters shall be in addition to filters replaced after testing.

1.3 SYSTEM DESCRIPTION

Each engine-generator set shall be provided and installed complete and totally functional, with all necessary ancillary equipment to include: air filtration; starting system; generator controls, protection, and isolation; instrumentation; lubrication; fuel system; cooling system; and engine exhaust system. Each engine-generator set shall satisfy the requirements specified in the Engine-Generator Parameter Schedule.

1.3.1 Engine-Generator Parameter Schedule

ENGINE-GENERATOR PARAMETER SCHEDULE

Power Rating	Emergency Standby
Overload Capacity (Prime applications only)	110% of Service Load for 1 hour in 12 consecutive hours
Service Load	1,500 kW (maximum) 1,500 kW (continuous)
Motor Starting kVA (Max.)	100 kVA
Power Factor	0.8 lagging
Engine-Generator Applications	stand-alone
Maximum Speed	1,800 rpm
Heat Exchanger Type	fin-tube (radiator)
Aftercooler Temperature (Max.)	29.4 deg. C
Governor Type	Isochronous
Frequency Bandwidth (steady state)	± 0.25 %
Governor Type	Droop
Frequency Regulation (droop) (No Load to Full Load)	3% (maximum)
Frequency Bandwidth (steady state)	± 20.25 %
Voltage Regulation (No Load to Full Load) (Stand alone applications)	± 2% (maximum)
Voltage Bandwidth (steady state)	± 1%
Frequency	60 Hz
Voltage	480 volts
Phases	3 Phase, Wye
Minimum Generator Subtransient Reactance	.12 %
Nonlinear Loads	469 kVA
Max Step Load Increase	25% of Service Load at .8 PF
Transient Recovery Time with Step Load Increase (Voltage)	3 seconds

ENGINE-GENERATOR PARAMETER SCHEDULE

Transient Recovery Time with Step Load Increase (Frequency)	3 seconds
Maximum Voltage Deviation with Step Load Increase	5% of rated voltage
Maximum Frequency Deviation with Step Load Increase	5% of rated frequency
Max Step Load Decrease (without shutdown)	100 % of Service Load at .8 PF
Max Time to Start and be Ready to Assume Load	10 seconds

1.3.2 Rated Output Capacity

Each engine-generator-set shall provide power equal to the sum of Service Load plus the machine's efficiency loss and associated ancillary equipment loads. Rated output capacity shall also consider engine and/or generator oversizing required to meet requirements in paragraph Engine-Generator Parameter Schedule.

1.3.3 Power Ratings

Power ratings shall be in accordance with EGSA 101P.

1.3.4 Transient Response

The engine-generator set governor and voltage regulator shall cause the engine-generator set to respond to the maximum step load changes such that output voltage and frequency recover to and stabilize within the operational bandwidth within the transient recovery time. The engine-generator set shall respond to maximum step load changes such that the maximum voltage and frequency deviations from bandwidth are not exceeded.

1.3.5 Reliability and Durability

Each standby engine-generator set shall have both an engine and a generator capable of delivering the specified power on a standby basis with an anticipated mean time between overhauls of no less than 5,000 hours operating with a load factor of 70%. Two like engines and two like generators shall be cited that have performed satisfactorily in a stationary power plant, independent and separate from the physical location of the manufacturer's and assembler's facilities, for standby without any failure to start, including all periodic exercise. Each like engine and generator shall have had no failures resulting in downtime for repairs in excess of 72 hours during two consecutive years of service. Like engines shall be of the same model, speed, bore, stroke, number and configuration of cylinders, and rated output capacity. Like generators shall be of the same model, speed, pitch, cooling, exciter, voltage regulator and rated output capacity.

1.4 GENERAL REQUIREMENTS

1.4.1 Engine-Generator Set

Each set shall consist of one engine, one generator, and one exciter mounted, assembled, and aligned on one base; and other necessary ancillary equipment which may be mounted separately. The set may be shipped in sections. Each set component shall be environmentally suitable for the location shown and shall be the manufacturer's standard product offered in catalogs for commercial or industrial use. Any nonstandard products or components and the reason for their use shall be specifically identified in paragraph SUBMITTALS.

1.4.2 Nameplates

Each major component of this specification shall have the manufacturer's name, type or style, model or serial number and rating on a plate secured to the equipment. As a minimum, nameplates shall be provided for:

Engines	Relays
Generators	Transformers (CT & PT)
Regulators	Day tanks
Pumps and pump motors	Governors
Generator Breaker	Air Starting System
Economizers	Heat exchangers (other than base mounted)

Where the following equipment is not provided as a standard component by the diesel engine generator set manufacturer, the nameplate information may be provided in the maintenance manual in lieu of nameplates.

Battery charger	Heaters
Switchboards	Exhaust mufflers
Switchgear	Silencers
Battery	Exciters

1.4.3 Personnel Safety Devices

Exposed moving parts, parts that produce high operating temperatures, parts which may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. The safety devices shall be installed so that proper operation of the equipment is not impaired.

1.4.4 Verification of Dimensions

Before performing any work, the premises shall be visited and all details of the work verified. The Contracting Officer shall be advised in writing of any discrepancies.

1.4.5 Conformance to Codes and Standards

Where equipment is specified to conform to requirements of any code or standard such as UL, NEMA, etc., the design, fabrication and installation shall also conform to the code.

1.4.6 Site Welding

Structural members shall be welded in accordance with Section 05090 WELDING, STRUCTURAL. For all other welding, procedures and welders shall be qualified in accordance with ASME BPV IX. Welding procedures qualified by others, and welders and welding operators qualified by a previously qualified employer may be accepted as permitted by ASME B31.1. Welder qualification tests shall be performed for each welder whose qualifications are not in compliance with the referenced standards. The Contracting Officer shall be notified 24 hours in advance of qualification tests. The qualification tests shall be performed at the work site if practical. The welder or welding operator shall apply his assigned symbol near each weld he makes as a permanent record.

1.4.7 Engine-Generator Set Enclosure

The engine-generator set enclosure shall be corrosion resistant and fully weather resistant. The enclosure shall contain all set components and provide ventilation to permit operation at Service Load under secured conditions. Doors shall be provided for access to controls and equipment requiring periodic maintenance or adjustment. The enclosure shall be capable of being removed without disassembly of the engine-generator set. The enclosure shall reduce the noise of the generator set to within the limits specified in the paragraph SOUND LIMITATIONS.

1.4.8 Fuel Tank

An integral fuel tank under-frame with floor and rupture basin.

1.4.9 Vibration Limitation

The maximum engine-generator set vibration in the horizontal, vertical, and axial directions shall be limited to 0.15 mm (peak-peak RMS), with an overall velocity limit of 24 mm/second RMS, for all speeds through 110% of rated speed.

1.4.10 Vibration Isolation

The engine-generator set shall be provided with a vibration-isolation system in accordance with the manufacturer's standard recommendation. Vibration-isolation systems shall be designed and qualified (as an integral part of the base and mounting system in accordance with the seismic parameters specified. Where the vibration-isolation system does not secure the base to the structure floor or unit foundation, seismic restraints shall be provided in accordance with the seismic parameters specified.

1.4.11 Seismic Requirements

Seismic requirements shall be in accordance with Sections 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT, 15070 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT and 16070 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

1.4.12 Harmonic Requirements

Non-linear loads to be served by the engine-generator set are as indicated. The maximum linear load demand (kVA @ PF) when non-linear loads will also be in use is as indicated.

1.4.13 Starting Time Requirements

Upon receipt of a signal to start, each engine generator set will start, reach rated frequency and voltage and be ready to assume load within the time specified. For standby sets used in emergency power applications, each engine generator set will start, reach rated frequency and voltage, and power will be supplied to the load terminals of the automatic transfer switch within the starting time specified.

1.4.14 Experience

Each component manufacturer shall have a minimum of 3 years experience in the manufacture, assembly and sale of components used with stationary diesel engine-generator sets for commercial and industrial use. The engine-generator set manufacturer/assembler shall have a minimum of 3 years experience in the manufacture, assembly and sale of stationary diesel engine-generator sets for commercial and industrial use.

1.4.15 Field Engineer

The engine-generator set manufacturer or assembler shall furnish a qualified field engineer to supervise the complete installation of the engine-generator set, assist in the performance of the onsite tests, and instruct personnel as to the operational and maintenance features of the equipment. The field engineer shall have attended the engine generator manufacturer's training courses on installation and operation and maintenance of engine generator sets.

1.5 STORAGE AND INSTALLATION

The Contractor shall properly protect material and equipment, in accordance with the manufacturers recommended storage procedures,before, during, and after installation. Stored items shall be protected from the weather and contamination. During installation, piping and similar openings shall be capped to keep out dirt and other foreign matter.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 Filter Elements

Fuel-oil, lubricating-oil, and combustion-air filter elements shall be manufacturer's standard.

2.1.2 Instrument Transformers

ANSI C12.11.

2.1.3 Pipe (Sleeves, Fuel/Lube-Oil, Compressed Air, Coolant, and Exhaust)

ASTM A 53, or ASTM A 106 steel pipe. Pipe smaller than 50 mm shall be Schedule 80. Pipe 50 mm and larger shall be Schedule 40.

a. Flanges and Flanged Fittings: ASTM A 181/A 181M, Class 60, or ASME B16.5, Grade 1, Class 150.

b. Pipe Welding Fittings: ASTM A 234/A 234M, Grade WPB or WPC, Class 150 or ASME B16.11, 1360.7 kg (3000 lb).

c. Threaded Fittings: ASME B16.3, Class 150.

d. Valves: MSS SP-80, Class 150.

e. Gaskets: Manufacturer's standard.

2.1.4 Pipe Hangers

MSS SP-58 and MSS SP-69.

2.1.5 Electrical Enclosures

NEMA ICS 6.

2.1.5.1 Power Switchgear Assemblies

NEMA SG 5.

2.1.5.2 Switchboards

NEMA PB 2.

2.1.5.3 Panelboards

NEMA PB 1.

2.1.6 Electric Motors

Electric motors shall conform to the requirements of NEMA MG 1. Motors shall have sealed ball bearings and a maximum speed of 1800 rpm. Motors shall be totally enclosed. Alternating current motors larger than 373 W (1/2 Hp) shall be of the squirrel-cage induction type for operation on 208 volts or higher, 60 Hz, and three-phase power. Alternating current motors 373 W (1/2 Hp) or smaller, shall be suitable for operation on 120 volts, 60 Hz, and single-phase power.

2.1.7 Motor Controllers

Motor controllers and starters shall conform to the requirements of NFPA 70 and NEMA ICS 2.

2.2 ENGINE

Each engine shall operate on No. 2-D diesel fuel conforming to ASTM D 975, shall be designed for stationary applications and shall be complete with ancillaries. The engine shall be a standard production model described in the manufacturer's catalog. The engine shall be naturally aspirated, supercharged, or turbocharged. The engine shall be 2- or 4-stroke-cycle and compression-ignition type. The engine shall be vertical in-line, V- or opposed-piston type, with a solid cast block or individually cast cylinders. Opposed-piston type engines shall have not less than four cylinders. Each block shall have a coolant drain port. Each engine shall be equipped with an overspeed sensor.

2.3 FUEL SYSTEM

The entire fuel system for each engine-generator set shall conform to the requirements of NFPA 30 and NFPA 37 and contain the following elements.

2.3.1 Pumps

2.3.1.1 Main Pump

Each engine shall be provided with an engine driven pump. The pump shall supply fuel at a minimum rate sufficient to provide the amount of fuel required to meet the performance indicated within the parameter schedule. The fuel flow rate shall be based on meeting the load requirements and all necessary recirculation.

2.3.2 Fuel Filter

A minimum of one full-flow fuel filter shall be provided for each engine. The filter shall be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. The filter shall have inlet and outlet connections plainly marked.

2.3.3 Relief/Bypass Valve

A relief/bypass valve shall be provided to regulate pressure in the fuel supply line, return excess fuel to a return line and prevent the build-up of excessive pressure in the fuel system.

2.3.4 Fuel Tank

An integral fuel tank underframe with floor rupture basin shall be supplied, consisting of the following: a rapture basin utilizing minimum 7 ga. steel channel perimeter walls and bottom; a UL listed (per UL 142) above ground, 72 hour capacity rectangular tank of minimum 12 ga. steel construction; and a floor system consisting of fabricated or structural steelcross members on centers averging 16 inches. The cross members will be overlaid with OSB board topped with 14 ga. steel diamond plate. This wood/steel combination must be used for acoustic isolation of the generator set from base. the tank shall hve venting and emergency venting per UL 142, lockable fill, low level and high level alarm contacts, and a DC electirc analog level gauge. The cross members shall incorporate 3/8 inch thick steel tapping paltes for genset mounting. The rupture basins hall have a float contact to indicate tank rupture, and the entire system shall be leak tested prior to installation.

2.4 LUBRICATION

Each engine shall have a separate lube-oil system conforming to NFPA 30 and NFPA 37. Each system shall be pressurized by engine-driven pumps. System pressure shall be regulated as recommended by the engine manufacturer. A pressure relief valve shall be provided on the crankcase for closed systems. The crankcase shall be vented in accordance with the manufacturer's recommendation except that it shall not be vented to the engine exhaust system. Crankcase breathers, if provided on engines installed in buildings or enclosures, shall be piped to vent to the outside. The system shall be readily accessible for service such as draining, refilling, etc. Each system shall permit addition of oil and have oil-level indication with the set operating. The system shall utilize an oil cooler as recommended by the engine manufacturer.

2.4.1 Lube-Oil Filter

One full-flow filter shall be provided for each pump. The filter shall be readily accessible and capable of being changed without disconnecting the piping or disturbing other components. The filter shall have inlet and outlet connections plainly marked.

2.4.2 Lube-Oil Sensors

Each engine shall be equipped with lube-oil pressure sensors. Pressure sensors shall be located downstream of the filters and provide signals for required indication and alarms.

2.4.3 Precirculation Pump

A motor-driven precirculation pump powered by the station battery, complete with motor starter shall be provided if recommended by the engine manufacturer.

2.5 COOLING SYSTEM

Each engine shall have its own cooling system. Each system shall operate automatically while its engine is running. The cooling system coolant shall use a combination of water and ethylene-glycol sufficient for freeze protection at the minimum winter outdoor temperature specified. The maximum temperature rise of the coolant across each engine shall not exceed that recommended and submitted in paragraph SUBMITTALS.

2.5.1 Coolant Pumps

Coolant pumps shall be the centrifugal type. Each engine shall have an engine-driven primary pump. Secondary pumps shall be electric motor driven and have automatic controllers.

2.5.2 Heat Exchanger

Each heat exchanger shall be of a size and capacity to limit the maximum allowable temperature rise in the coolant across the engine to that recommended and submitted in paragraph SUBMITTALS for the maximum summer outdoor design temperature and site elevation. Each heat exchanger shall be corrosion resistant, suitable for service in ambient conditions of application.

2.5.2.1 Fin-Tube-Type Heat Exchanger (Radiator)

Heat exchanger may be factory coated with corrosive resistant film, provided that correction measures are taken to restore the heat rejection capability of the radiator to the initial design requirement via over sizing, or other compensating methods. Internal surfaces shall be compatible with liquid fluid coolant used. Materials and coolant are subject to approval by the Contracting Officer. Heat exchangers shall be pressure type incorporating a pressure valve, vacuum valve and a cap. Caps shall be designed for pressure relief prior to removal. Each heat exchanger and the entire cooling system shall be capable of withstanding a minimum pressure of 48 kPa and shall be protected with a strong grille or screen guard. Each heat exchanger shall have at least two tapped holes; one tapped hole shall be equipped with a drain cock, the rest shall be plugged.

2.5.3 Temperature Sensors

Each engine shall be equipped with coolant temperature sensors. Temperature sensors shall provide signals for pre-high and high indication and alarms.

A weatherproof, sound attenuated, walk-in type enclosure shall be provided to house the engine/generator and accessories. The enclosure is to be in compliance with the National Electrical Code (NEC), and the National Fire

Protection Association (NFPA) for clearance around electrical equipment as specified. The enclosure shall conform to the following design criteria.

Rigidity wind test equal to 115 mph

Roof load equal to 50 lbs. per sf

Floor load equal to 200 lbs. per sf

Rain test equal to 4" per hour

Certified to meet the BOCA basic building and mechanical codes.

Test data on similar construction by manufacturer.

Enclosure will consist of stressed skin, semi-monocoque construction.

The system shall include a cooling and combustion air inlet silencer section, an equipment enclosure section, and a cooling air discharge silencer section. It shall be designed to reduce source noise by an estimated average 25 dBA as measured at 1 meter. The enclosure shall be designed as follows:

Roof and walls shall be of one-piece semi-monocoque construction. All framing members shall be 6063-T6 aluminum or aluminized steel. Skin material shall be minimum thickness of 0.040" prepainted aluminum (roof shall be mill finish). A minimum of six colors shall be available for enclosure exterior. Skin panels shall be hard-riveted to framing members on 3" centers maximum. Pop rivets and bolts are not acceptable fasteners to attach exterior skin to framing. Roof assembly shall be cambered to aid in rain runoff.

Insulation in walls and roof shall be semi-rigid, thermo-acoustic, thickness as required to meet the noise criteria specified. Lining shall be perforated, mill finish aluminum. Self-adhesive foam and loose or bat-type insulating materials will not be accepted.

Four point lifting provisions shall be provided at or near the enclosure base, with capacity suitable for rigging the entire assembly. Quality assurance procedures of the manufacturer shall include regular testing of the lift devices.

Two (2) single personnel access doors shall be provided. Door shall consist of an extruded aluminum frame with skin material matching enclosure. Door shall be fully gasketed to form a weathertight perimeter seal. Hinges shall be forged aluminum with stainless steel pins, handle shall be stainless steel and padlockable, and lock mechanism shall be 3 point, with panic hardware to allow opening from inside even when padlocked.

Air handling shall be as follows: Air will enter the enclosure through removable hood(s) or an integral, baffled plenum. Motor operated damper(s) will be provided, wired to open upon engine startup. Radiator discharge will be through a gravity operated damper and into a hood or vertical plenum, as dictated by air flow. The system shall not exceed 0.5" WG total external static pressure to ensure adequate air flow for cooling and combustion.

A bolt-in-place removable wall panel shall be provided for maintenance and/or equipment installation.

Enclosure manufacturer shall provide all necessary hardware and internally mount the specified exhaust silencer(s) and maintain the weatherproof integrity of the system. Silencer and exhaust flex shall be insulated.

The enclosure shall include a 120/208V, 1 phase, 3W, 100A load center. The enclosure shall include AC and DC lighting, and GFI duplex receptacles. DC lights to have timer type switch. All devices in the enclosure, including specified generator set accessories, shall be prewired in EMT by enclosure manufacturer. In addition, the manufacturer shall perform the system integration of all components in the enclosure, mechanical and electrical.

2.6 SOUND LIMITATIONS

The noise generated by the diesel generator set operating at 100 percent load shall not exceed the following sound pressure levels in any of the indicated frequencies when measured in a free field at a radial distance of 22.9 feet 7 meters at 45 degrees apart in all directions.

Frequency Band (Hz)	Maximum Acceptable Pressure Level (Decibels)
31	87
63	87
125	78
250	70
500	64
1,000	58
2,000	54
4,000	52
8,000	51

The noise generated by the installed diesel generator set operating at 100 percent load shall not exceed the following sound pressure levels in any of the indicated frequencies when measured at a distance of 22.9m from the end of the exhaust and air intake piping directly along the path of intake and discharge for horizontal piping; or at a radius of 22.9m from the engine at 45 degrees apart in all directions for vertical piping.

Frequency Band (Hz)	Maximum Acceptable Pressure Level (Decibels)
31	87
63	87
125	78
250	70
500	64
1,000	58
2,000	54
4,000	52

Frequency Band (Hz)	Maximum Acceptable Pressure Level (Decibels)
8,000	51

2.7 AIR INTAKE EQUIPMENT

Filters and silencers shall be provided in locations that are convenient for servicing. The silencer shall be of the high-frequency filter type, located in the air intake system as recommended by the engine manufacturer. Silencer shall be capable of reducing the noise level at the air intake so that the indicated pressure levels specified in paragraph SOUND LIMITATIONS will not be exceeded. A combined filter-silencer unit meeting requirements for the separate filter and silencer items may be provided. Expansion elements in air-intake lines shall be copper.

2.8 EXHAUST SYSTEM

The system shall be separate and complete for each engine. Piping shall be supported to minimize vibration. Where a V-type engine is provided, a V-type connector, with necessary flexible sections and hardware, shall connect the engine exhaust outlets.

2.8.1 Flexible Sections and Expansion Joints

A flexible section shall be provided at each engine and an expansion joint at each muffler. Flexible sections and expansion joints shall have flanged connections. Flexible sections shall be made of convoluted seamless tube without joints or packing. Expansion joints shall be the bellows type. Expansion and flexible elements shall be stainless steel suitable for diesel-engine exhaust gas at the maximum exhaust temperature that is specified by the engine manufacturer. Expansion and flexible elements shall be capable of absorbing vibration from the engine and compensation for thermal expansion and contraction.

2.8.2 Exhaust Muffler

A chamber type exhaust muffler shall be provided. The muffler shall be constructed of welded steel and designed for outside mounting. Eyebolts, lugs, flanges, or other items shall be provided as necessary for support in the location and position indicated. Pressure drop through the muffler shall not exceed the recommendations of the engine manufacturer. Outside mufflers shall be zinc coated or painted with high temperature 400 degrees resisting paint. The muffler and exhaust piping together shall reduce the noise level to less than the maximum acceptable level listed for sound limitations in paragraph SOUND LIMITATIONS. The muffler shall have a drain valve, nipple, and cap at the low-point of the muffler.

2.8.3 Exhaust Piping

Horizontal sections of exhaust piping shall be sloped downward away from the engine to a drip leg for collection of condensate with drain valve and cap. Changes in direction shall be long radius. Vertical exhaust piping shall be provided with a hinged, gravity-operated, self-closing, rain cover.

2.9 PYROMETER

A pyrometer, multi-point selector switch, and individual thermocouples with calibrated leads shall be provided to show the temperature in each engine cylinder and the combined exhaust. For a supercharged engine, additional points, thermocouples and leads shall be provided to show the temperature in the turbocharger exhaust gas outlet and combustion air discharge passages. Graduated scale length shall be not less than 150 mm. The selector switch shall be double pole, with an "off" position, one set of points for each thermocouple, and suitable indicating dial. The pyrometer, thermocouples, leads and compensating devices shall be calibrated to show true exhaust temperature within plus or minus 1% above the highest temperature encountered at 110% load conditions.

2.10 EMISSIONS

The finished installation shall comply with Federal, state, and local regulations and restrictions regarding the limits of emissions, as listed below.

NOx emissions at 100% load shall not exceed 9.307 kg/hr.

2.11 STARTING SYSTEM

The starting system for standby engine generator sets used in emergency applications shall be in accordance with NFPA 99 and NFPA 110 and as follows.

2.11.1 Controls

An engine control switch shall be provided with functions including: run/start(manual), off/reset, and, automatic mode. Start-stop logic shall be provided for adjustable cycle cranking and cooldown operation. The logic shall be arranged for manual starting and fully automatic starting in accordance with paragraph AUTOMATIC ENGINE-GENERATOR-SET SYSTEM OPERATION. Electrical starting systems shall be provided with an adjustable cranking limit device to limit cranking periods from 1 second up to the maximum duration.

2.11.2 Capacity

The starting system shall be of sufficient capacity, at the maximum outdoor summer temperature specified to crank the engine without damage or overheating. The system shall be capable of providing a minimum of three cranking periods with 15 second intervals between cranks. Each cranking period shall have a maximum duration of 15 seconds.

2.11.3 Electrical Starting

Manufacturers recommended dc system, utilizing a negative circuit ground.

2.11.3.1 Battery

A starting battery system shall be provided and shall include the battery, battery rack, intercell connectors, spacers, automatic battery charger with overcurrent protection, metering and relaying. The battery shall be in accordance with SAE J 537. Critical system components (rack, protection, etc.) shall be sized to withstand the seismic acceleration forces specified. The battery shall be nickel-cadmium, with sufficient capacity, at the minimum outdoor and maximum indoor temperature specified, to provide the specified cranking periods. Valve-regulated lead-acid batteries are not acceptable.

2.11.3.2   Battery Charger

A current-limiting battery charger, conforming to UL 1236, shall be provided and shall automatically recharge the batteries. The charger shall be capable of an equalize-charging rate for recharging fully depleted batteries within 24 hours and a floating charge rate for maintaining the batteries at fully charged condition. An ammeter shall be provided to indicate charging rate. A voltmeter shall be provided to indicate charging voltage. A timer shall be provided for the equalize-charging-rate setting. A battery is considered to be fully depleted when the output voltage falls to a value which will not operate the engine generator set and its components.

2.11.4   Cylinder Injection

Starting shall be accomplished by admitting compressed air into two or more engine cylinders through a timing valve, or through a distributor into a sufficient number of cylinders to assure successful starting regardless of piston positions.

2.11.5   Starting Aids

The manufacturer shall provide one or more of other following methods to assist engine starting.

2.11.5.1   Jacket-Coolant Heaters

A thermostatically controlled electric heater shall be mounted in the engine coolant jacketing to automatically maintain the coolant within plus or minus 1.7 degrees C   of the control temperature. The heater shall operate independently of engine operation so that starting times are minimized. Power for the heaters shall be 208 volts ac via an integral control transformer pre-wired to enclosure load center.

a. Standby Rated Sets

The control temperature shall be the temperature recommended by the engine manufacturer to meet the starting time specified at the minimum winter outdoor temperature.

2.11.6   Exerciser

The exerciser shall be in accordance with Section 16410, AUTOMATIC TRANSFER AND BY-PASS/ISOLATION SWITCHES.

2.12   GOVERNOR

Each engine shall be provided with a governor which maintains the frequency within a bandwidth of the rated frequency, over a steady-state load range of zero to 100% of rated output capacity. The governor shall be configured for safe manual adjustment of the speed/frequency during operation of the engine-generator set, without special tools, from 90 to 110% of the rated speed/frequency, over a steady state load range of 0 to 100% or rated capacity.

2.12.1   Governor Performance

Isochronous governors shall maintain the midpoint of the frequency bandwidth at the same value for steady-state loads over the range of zero to 100% of rated output capacity.

2.13 GENERATOR

Each generator shall be of the synchronous type, one or two bearing, conforming to NEMA MG 1, equipped with winding terminal housings in accordance with NEMA MG 1, equipped with an amortisseur winding, and directly connected to the engine. Insulation shall be Class F. Generator design shall protect against mechanical, electrical and thermal damage due to vibration, 25% overspeeds, or voltages and temperatures at a rated output capacity of 110% for prime applications and 100% for standby applications. Generator ancillary equipment shall meet the short circuit requirements of NEMA MG 1. Frames shall be the drip-proof type.

2.13.1 Current Balance

At 100% rated output capacity, and load impedance equal for each of the 3 phases, the permissible current difference between any 2 phases shall not exceed 2% of the largest current on either of the 2 phases.

2.13.2 Voltage Balance

At any balanced load between 75 and 100% of rated output capacity, the difference in line-to-neutral voltage among the 3 phases shall not exceed 1% of the average line-to-neutral voltage. For a single-phase load condition, consisting of 25% load at unity power factor placed between any phase and neutral with no load on the other 2 phases, the maximum simultaneous difference in line-to-neutral voltage between the phases shall not exceed 3% of rated line to neutral voltage. The single-phase load requirement shall be valid utilizing normal exciter and regulator control. The interpretation of the 25% load for single phase load conditions means 25% of rated current at rated phase voltage and unity power factor.

2.13.3 Waveform

The deviation factor of the line-to-line voltage at zero load and at balanced rated output capacity shall not exceed 10%. The RMS of all harmonics shall be less than 5.0% and that of any one harmonic less than 3.0% of the fundamental at rated output capacity. Each engine-generator shall be designed and configured to meet the total harmonic distortion limits of IEEE Std 519.

2.14 EXCITER

The generator exciter shall be of the brushless type. Semiconductor rectifiers shall have a minimum safety factor of 300% for peak inverse voltage and forward current ratings for all operating conditions, including 110% generator output at 4O degrees C ambient. The exciter and regulator in combination shall maintain generator-output voltage within the limits specified.

2.15 VOLTAGE REGULATOR

Each generator shall be provided with a solid-state voltage regulator, separate from the exciter. The regulator shall maintain the voltage within a bandwidth of the rated voltage, over a steady-state load range of zero to 100% of rated output capacity. Regulator shall be configured for safe manual adjustment of the engine-generator voltage output without special tools, during operation, from 90 to 110% of the rated voltage over the steady state load range of 0 to 100% of rated output capacity. Regulation drift shall not exceed plus or minus 0.5% for an ambient temperature change of 20 degrees C.

2.15.1   Steady State Performance (Regulation or Voltage Droop)

The voltage regulator shall have a maximum droop of 2% of rated voltage over a load range from 0 to 100% of rated output capacity and automatically maintain the generator output voltage within the specified operational bandwidth.

2.16   GENERATOR ISOLATION AND PROTECTION

Devices necessary for electrical protection and isolation of each engine-generator set and its ancillary equipment shall be provided. The generator circuit breaker (IEEE Device 52) ratings shall be consistent with the generator rated voltage and frequency, with continuous, short circuit withstand, and interrupting current ratings to match the generator capacity. The generator circuit breaker shall be electrically operated. A set of surge capacitors, to be mounted at the generator terminals shall be provided. Monitoring and control devices shall be as specified in paragraph GENERATOR PANEL.

2.16.1   Switchboards

Switchboards shall be free-standing, metal-enclosed, general purpose, 3-phase, 4-wire, 600 volt rated, with neutral bus and continuous ground bus, conforming to NEMA PB 2 and UL 891 and NEMA/12. Neutral bus and ground bus capacity shall be full capacity. Panelboards shall conform to NEMA PB 1. Enclosure designs, construction, materials and coatings shall be suitable for the application and environment. Bus continuous current rating shall be at least equal to the generator rating and correspond to the UL listed current ratings specified for panelboards and switchboards. Current withstand short circuit rating shall be equal to the breaker interrupting rating as indicated. Buses shall be copper. Refer to Contract Documents for circuit breaker sizes.

2.16.2   Devices

Switches, circuit breakers, switchgear, fuses, relays, and other protective devices shall be as specified in Section 16475 COORDINATED POWER SYSTEM PROTECTION.

2.17   SAFETY SYSTEM

Devices, wiring, remote panels, local panels, etc. shall be provided and installed as a complete system to automatically activate the appropriate signals and initiate the appropriate actions. The safety system shall be provided with a self-test method to verify its operability. Alarm signals shall have manual acknowledgment and reset devices. The alarm signal systems shall reactivate for new signals after acknowledgment is given to any signal. The systems shall be configured so that loss of any monitoring device shall be dealt with as an alarm on that system element.

2.17.1   Audible Signal

The audible alarm signal shall sound at a frequency of 70 Hz at a volume of

75 dB at 3.1 m . The sound shall be continuously activated upon alarm and silenced upon acknowledgment.

2.17.2   Visual Signal

The visual alarm signal shall be a panel light. The light shall be normally off, activated to be blinking upon alarm. The light shall change to continuously lit upon acknowledgement. If automatic shutdown occurs, the display shall maintain activated status to indicate the cause of failure and shall not be reset until cause of alarm has been cleared and/or restored to normal condition. Shutdown alarms shall be red; all other alarms shall be amber.

2.17.3   Alarms and Action Logic

2.17.3.1   Shutdown

Simultaneous activation of the audible signal, activation of the visual signal, stopping the engine, and opening the generator main circuit breakers shall be accomplished.

2.17.3.2   Problem

Activation of the visual signal shall be accomplished.

2.17.4   Local Alarm Panel

A local alarm panel shall be provided with the following shutdown and alarm functions in accordance with NFPA 99 and including the listed Corps of Engineer requirements mounted either on or adjacent to the engine generator set.

Device/Condition /Function	What/Where/Size	NFPA 99	NFPA 110 Level 1	NFPA 110 Level 2	Corps of Engrs Required
Shutdowns w/Alarms					
High engine temperature	Automatic/jacket/ water/cylinder	SD/CP VA	SD/CP VA	SD/CP VA	SD VA
Low lube-oil pressure	Automatic/pressure/ level	SD/CP VA	SD/CP VA	SC/CP VA	SD VA
Overspeed Shutdown& Alarm	(110 percent (± 2 % of rated speed)	SD/CP VA	SD/CP VA	SD/CP VA	SD VA
Overcrank, Failure to start	Automatic/Failure to start	SD/CP VA	SD/CP VA	SD/CP VA	
	when used		SD/CP VA	SD/CP VA	
Air shutdown damper (200-600kW)	When Used		SD/CP VA	SD/CP VA	
Fuel tank overfill limit	Automatic/Fuel Tank/Level				SD(Pump) CP VA

Device/Condition /Function	What/Where/Size	NFPA 99	NFPA 110 Level 1	NFPA 110 Level 2	Corps of Engrs Required
indication & transfer pump shutdown (95 % volume)					
Red emergency stop switch	Manual Switch		SD/CP VA	SD/CP VA	SD VA
Alarms					
Fuel Tank (low fuel Limit indication) (70 percent volume remaining)	Automatic/Fuel Tank Level				CP VA
Low fuel level	Main tank, 3 hrs remaining	VA/AA	CP VA	CP VAO	CP VA
Low Coolant Temperature	jacket water	CP VA	CP VA	CP VA	
Pre-High Temperature	jacket water/ cylinder	CP VA	CP VA	CP VAO	CP VA
Pre-Low Lube-oil Pressure		CP VA			CP VA
High battery Voltage			CP VA	CP VAO	
Low battery Voltage			CP VA	CP VAO	
Battery charger AC Failure	AC supply not available		CP VA	CP VAO	
Control switch not in AUTO			CP VA	CP VAO	
Low starting Air pressure			CP VA	CP VAO	
Low starting hydraulic pressure			CP VA	CP VAO	

SD - Shut Down
CP - On Control Panel
VA - Visual Alarm
AA - Audible Alarm
O - Optional

2.17.5   Time-Delay on Alarms

For startup of the engine-generator set, time-delay devices shall be installed bypassing the low lubricating oil pressure alarm during cranking, and the coolant-fluid outlet temperature alarm. The lube-oil time-delay device shall return its alarm to normal status after the engine starts. The coolant time-delay device shall return its alarm to normal status 5 minutes after the engine starts.

2.17.6   Remote Alarm Panel

A remote alarm panel shall be provided in accordance with NFPA 99and as follows.

Device/Condition/Function	What/Where/Size	NFPA 99	NFPA 110 Level 1	NFPA 110 Level 2
Remote annunciator panel	Battery Powered		Alarms	
Loads on genset		VA		
Battery charger malfunction		VA		
Low lube-oil	Pressure/level	VA/AA	AA	AAO
Low temperature	Jacket water	VA/AA	AA	AAO
High temperature	Jacket water/ cylinder	VA/AA	AA	AAO
Low fuel level	Main tank, 3 hrs remaining	VA/AA	AA	AAO
Overcrank	Failure to start	VA/AA	AA	AAO
Overspeed		VA/AA	AA	AAO
Pre-high temperature	Jacket water/ cylinder		AA	
Control switch not in AUTO			AA	
Common alarm contacts for local & remote common alarm			X	X
Audible alarm silencing switch			X	O
Air shutdown damper	When used		AA	AAO
Common fault alarm			AA	

X - Required
SD - Shutdown
CP - On Control Panel
VA - Visual Alarm
AA - Audible Alarm
O - Optional

2.18   PANELS

Each panel shall be of the type and kind necessary to provide specified functions. Panels shall be mounted on the engine-generator set base by vibration/shock absorbing type mountings as shown. Instruments shall be mounted flush or semiflush. Convenient access to the back of panels shall be provided to facilitate maintenance. Instruments shall be calibrated using recognized industry calibration standards. Each panel shall be provided with a panel identification plate which clearly identifies the panel function. Each instrument and device on the panel shall be provided with a plate which clearly identifies the device and its function as indicated. Switch plates shall clearly identify the switch-position function.

2.18.1 Enclosures

Enclosures shall be designed for the application and environment, conforming to NEMA ICS 6 and NEMA 12 . Locking mechanisms shall be keyed alike.

2.18.2 Analog

Analog electrical indicating instruments shall be in accordance with ANSI C39.1 with semiflush mounting. Switchboard, switchgear, and control-room panel-mounted instruments shall have 250 degree scales with an accuracy of not less than 99%. Unit-mounted instruments shall be the manufacturer's standard have 100 degree scales with an accuracy of not less than 98%. The instrument's operating temperature range shall be minus 20 to plus 65 degrees C.   Distorted generator output voltage waveform of a crest factor less than 5 shall not affect metering accuracy for phase voltages, hertz and amps.

2.18.3 Electronic

Electronic indicating instruments shall be true RMS indicating instruments, 100% solid state, state-of-the-art, microprocessor controlled to provide specified functions. Control, logic, and function devices shall be compatible as a system, sealed, dust and water tight, and shall utilize modular components with metal housings and digital instrumentation. An interface module shall be provided to decode serial link data from the electronic panel and translate alarm, fault and status conditions to set of relay contacts. Instrument accuracy shall be not less than 98% for unit mounted devices and 99% for control room, panel mounted devices, throughout a temperature range of minus 20 to plus 65 degrees C.   Data display shall utilize LED or back lit LCD. Additionally, the display shall provide indication of cycle programming and diagnostic codes for troubleshooting. Numeral height shall be 13 mm.

2.18.4 Parameter Display

Indication or readouts of the tachometer, lubricating-oil pressure, ac voltmeter, ac ammeter, frequency meter, and safety system parameters shall be provided. A momentary switch shall be specified for other panels.

2.19 AUTOMATIC ENGINE-GENERATOR-SET SYSTEM OPERATION

Fully automatic operation shall be provided for the following operations: engine-generator set starting and load transfer upon loss of normal source; retransfer upon restoration of the normal source; sequential starting; paralleling, and load-sharing for multiple engine-generator sets; and stopping of each engine-generator set after cool-down. Devices shall automatically reset after termination of their function.

2.19.1 Automatic Transfer Switch

Automatic transfer switches shall be in accordance with Section 16410 AUTOMATIC TRANSFER AND BY-PASS/INSOLATION SWITCHES.

2.19.2 Monitoring and Transfer

Devices shall be provided to monitor voltage and frequency for the normal power source and each engine-generator set, and control transfer from the normal source and retransfer upon restoration of the normal source. Functions, actuation, and time delays shall be as described in Section 16410 AUTOMATIC TRANSFER AND BY-PASS/ISOLATION SWITCHES.

2.20 BASE

The base shall be constructed of steel. The base shall be designed to rigidly support the engine-generator set and fuel tank, ensure permanent alignment of rotating parts, be arranged to provide easy access to allow changing of lube-oil, and ensure that alignment is maintained during shipping and normal operation. The base shall permit skidding in any direction during installation and shall withstand and mitigate the affects of synchronous vibration of the engine and generator. The base shall be provided with suitable holes for anchor bolts diameter holes for anchor bolts and jacking screws for leveling.

2.21 THERMAL INSULATION

Thermal insulation shall be as specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.22 PAINTING AND FINISHING

The engine-generator set shall be cleaned, primed and painted in accordance with the manufacturer's standard color and practice.

2.23 FACTORY INSPECTION AND TESTS

The factory tests shall be performed on each engine-generator set. The component manufacturer's production line test is acceptable as noted. Each engine-generator set shall be run not less than 1 hour at rated output capacity prior to inspections. Inspections shall be completed and all necessary repairs made, prior to testing. Engine generator controls and protective devices that are provided by the generator set manufacturer as part of the standard package shall be used for factory tests. When controls and switchgear are not provided as part of the generator set manufacturer's standard package, the actual controls and protective devices provided for the project are not required to be used during the factory test. The Contracting Officer may provide one or more representatives to witness inspections and tests.

2.23.1 Factory Inspection

Inspections shall be performed prior to beginning and after completion of testing of the assembled engine-generator set. Inspectors shall look for leaks, looseness, defects in components, proper assembly, etc. and any item found to be in need of correction shall be noted as a necessary repair. The following checklist shall be used for the inspection:

INSPECTION ITEM	GOOD	BAD	NOTES
1. Drive belts			
2. Governor and adjustments			
3. Engine timing mark			
4. Starting motor			
5. Starting aids			
6. Coolant type and concentration			
7. Radiator drains			

8. Block coolant drains
9. Coolant fill level
10. All coolant line connections
11. All coolant hoses
12. Combustion air filter
13. Combustion air silencer
14. Lube oil type
15. Lube oil sump drain
16. Lube-oil filter
17. Lube-oil-level indicator
18. Lube-oil-fill level
19. All lube-oil line connections
20. All lube-oil lines
21. Fuel type and amount
22. All fuel-line connections
23. All fuel lines
24. Fuel filter
25. Coupling and shaft alignment
26. Voltage regulators
27. Battery-charger connections
28. All wiring connections
29. Instrumentation
30. Hazards to personnel
31. Base
32. Nameplates
33. Paint
34. Switchboard

2.23.2 Factory Tests

On engine-generator set tests where the engine and generator are required to be connected and operated together, the load power factor shall be the power factor specified in the engine generator set parameter schedule .8 power factor. For engine-generator set with dual-fuel operating capability the following tests shall be performed using the primary fuel type. Electrical measurements shall be performed in accordance with IEEE Std 120. Definitions of terms are in accordance with IEEE Std 100. Temperature limits in the rating of electrical equipment and for the evaluation of electrical insulation shall be in accordance with IEEE Std 1. In the following tests where measurements are to be recorded after stabilization of an engine-generator set parameter (voltage, frequency, current, temperature, etc.), stabilization is considered to have occurred when measurements are maintained within the specified bandwidths or tolerances, for a minimum of four consecutive readings. Tests specifically for the generator may be performed utilizing any prime mover.

a. Insulation Resistance for Stator and Exciter Test, IEEE Std 115 and IEEE Std 43, to the performance criteria in NEMA MG 1, Part 22. Generator manufacturer's production line test is acceptable.

b. High Potential Test, per IEEE Std 115 and NEMA MG 1, test voltage in accordance with NEMA MG 1. Generator manufacturer's production line test is acceptable.

c. Winding Resistance Test, Stator and Exciter, per IEEE Std 115. Generator manufacturer's production line test is acceptable.

d. Overspeed Vibration Test, per IEEE Std 115 to the performance criteria in NEMA MG 1. The test shall be performed at 110% of rated speed for 5 minutes. The vibration shall be measured at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Vibration amplitude and speed shall be recorded at one minute intervals.

e. Phase Balance Voltage Test, to the performance criteria specified in paragraph GENERATOR. This test can be performed with any prime mover. Generator manufacturer's production line test results are acceptable.

(1) Start and operate the generator at no load.

(2) Adjust a regulated phase voltage (line-to-neutral) to rated voltage.

(3) Read and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(4) Apply 75% rated load and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(5) Apply rated load and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(6) Calculate average line-neutral voltage and percent deviation of individual line-neutral voltages from average for each load condition.

f. Current Balance on Stator Winding Test, by measuring the current on each phase of the winding with the generator operating at 100 % of Rated Output Capacity, with the load impedance equal for each of the three phases: to the performance criteria specified in paragraph GENERATOR.

g. Voltage Waveform Deviation and Distortion Test per IEEE Std 115 to the performance criteria specified in paragraph GENERATOR. High-speed recording instruments capable of recording voltage waveform deviation and all distortion, including harmonic distortion shall be used. Representation of results shall include appropriate scales to provide a means to measure and interpret results.

h. Voltage and Frequency Droop Test. Verify that the output voltage and frequency are within the specified parameters as follows:

(1.) With the generator operating at no load, adjust voltage and frequency to rated voltage and frequency. Record the generator output frequency and line-line and line-neutral voltages.

(2.) Increase load to Rated Output Capacity. Record the generator output frequency and line-line and line-neutral voltages.

3. Calculate the percent droop for voltage and frequency with the following equations:

$$\text{Voltage droop \%} = \frac{(\text{No-Load Volts}) - (\text{Rated Capacity volts})}{(\text{Service-Load Volts})} \times 100$$

$$\text{Frequency droop \%} = \frac{(\text{No-Load Hertz}) - (\text{Rated Capacity hertz})}{(\text{Service-Load hertz})} \times 100$$

4. Repeat steps 1 through 3 two additional times without making any adjustments.

i. Frequency and Voltage Stability and Transient Response. Verify that the engine-generator set responds to addition and dropping of blocks of load in accordance with the transient response requirements. Document maximum voltage and frequency variation from bandwidth and verify that voltage and frequency return to and stabilize within the specified bandwidth, within the specified response time period. Document results in tabular form and with high resolution, high speed strip chart recorders or comparable digital recorders, as approved by the Contracting Officer. Tabular data shall include the following:

Ambient temperature (at 15 minute intervals).

Generator output current (before and after load changes).

Generator output voltage (before and after load changes).

Frequency (before and after load changes).

Generator output power (before and after load changes).

Graphic representations shall include the actual instrument trace of voltage and frequency showing: charts marked at start of test; observed steady-state band; mean of observed band; momentary overshoot and undershoot (generator terminal voltage and frequency) and recovery time for each load change together with the voltage and frequency maximum and minimum trace excursions for each steady state load condition prior to and immediately following each load change. Generator terminal voltage and frequency transient recovery time for each step load increase and decrease.

(1.) Perform and record engine manufacturer's recommended prestarting checks and inspections.

(2.) Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period and no load. Verify stabilization of voltage and frequency within specified bandwidths.

(3.) With the unit at no load, apply the Maximum Step Load Increase.

(4.) Apply load in steps equal to the Maximum Step Load Increase until the addition of one more step increase will exceed the Service Load.

(5.) Decrease load to the unit such that addition of the Maximum Step Load Increase will load the unit to 100% of Service Load.

(6.) Apply the Maximum Step Load Increase.

(7.) Decrease load to zero percent in steps equal to the Maximum Step Load Decrease.

(8.) Repeat steps 3. through 7.

j. Test Voltage Unbalance with Unbalanced Load (Line-to-Neutral) to the performance criteria specified in paragraph GENERATOR. Prototype test data is acceptable in lieu of the actual test. This test may be performed using any prime mover.

(1.) Start and operate the generator set at rate voltage, no load, rated frequency, and under control of the voltage regulator. Read and record the generator frequency, line-to-neutral voltages, and the line-to-line voltages.

(2.) Apply the specified load between terminals L_1-L_2, L_2-L_0, and L_3-L_0 in turn. Record all instrument readings at each line-neutral condition.

(3.) Express the greatest difference between any two of the line-to-line voltages and any two of the line-to-neutral voltages as a percent of rated voltage.

(4.) Compare the largest differences expressed in percent with the maximum allowable difference specified.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION

Installation shall provide clear space for operation and maintenance in accordance with NFPA 70 and IEEE C2. Installation of pipe, duct, conduit, and ancillary equipment shall be configured to facilitate easy removal and replacement of major components and parts of the engine-generator set.

3.2 PIPING INSTALLATION

Piping shall be welded. Connections at valves shall be flanged. Connections at equipment shall be flanged except that connections to the diesel engine may be threaded if the diesel-engine manufacturers standard connection is threaded. Except where otherwise specified, welded flanged fittings shall be utilized to allow for complete dismantling and removal of each piping system from the facility without disconnecting or removing any portion of any other system's equipment or piping. Connections to equipment shall be made with vibration-isolation-type flexible connectors. Piping and tubing shall be supported and aligned to prevent stressing of flexible hoses and connectors. Pipes extending through the roof shall be properly flashed. Piping shall be installed clear of windows, doors and openings, to permit thermal expansion and contraction without damage to joints or hangers, and shall be installed with a 15 mm drain valve with cap at each low point.

3.2.1 Support

Hangers, inserts, and supports shall be of sufficient size to accommodate any insulation and shall conform to MSS SP-58 and MSS SP-69. Supports shall be spaced not more than 2.1 m on center for pipes 50 mm in diameter or less, not more than 3.6 m on center for pipes larger than 50 mm but smaller than 100 mm in diameter, and not more than 5.2 m on center for pipes larger than 100 mm in diameter. Supports shall be provided at pipe bends or change of direction.

3.2.1.1   Ceiling and Roof

Exhaust piping shall be supported with appropriately sized Type 41 single pipe roll and threaded rods; all other piping shall be supported with appropriately sized Type 1 clevis and threaded rods.

3.2.1.2   Wall

Wall supports for pipe shall be made by suspending the pipe from appropriately sized Type 33 brackets with the appropriate ceiling and roof pipe supports.

3.2.2   Flanged Joints

Flanges shall be Class 125 type, drilled, and of the proper size and configuration to match the equipment and diesel engine connections. Flanged joints shall be gasketed and made up square and tight.

3.2.3   Cleaning

After fabrication and before assembly, piping interiors shall be manually wiped clean of debris.

3.2.4   Pipe Sleeves

Pipes passing through construction such as ceilings, floors, or walls shall be fitted with sleeves. Each sleeve shall extend through and be securely fastened in its respective structure and shall be cut flush with each surface. The structure shall be built tightly to the sleeve. The inside diameter of each sleeve shall be minimum 15 mm, and where pipes pass through combustible materials 25 mm larger than the outside diameter of the passing pipe or pipe insulation/covering.

3.3   ELECTRICAL INSTALLATION

Electrical installation shall comply with NFPA 70, IEEE C2, and Section 16415 ELECTRICAL WORK, INTERIOR.

3.3.1   Vibration Isolation

Flexible fittings shall be provided for conduit, cable trays, and raceways attached to engine-generator sets. Metallic conductor cables installed on the engine generator set and from the engine generator set to equipment not mounted on the engine generator set shall be flexible stranded conductor. Terminations of conductors on the engine generator set shall be crimp-type terminals or lugs.

3.4   FIELD PAINTING

Field painting shall be as specified in Section 09900 PAINTING, GENERAL.

3.5   ONSITE INSPECTION AND TESTS

3.5.1   Test Conditions

3.5.1.1   Data

Measurements shall be made and recorded of all parameters necessary to verify that each set meets specified parameters. If the results of any test step are not satisfactory, adjustments, replacements, or repairs shall be made and the step repeated until satisfactory results are obtained. Unless otherwise indicated, data shall be recorded in 15 minute intervals during engine-generator set operation and shall include: readings of all engine-generator set meters and gauges for electrical and power parameters; oil pressure; ambient temperature; and engine temperatures available from meters and gauges supplied as permanent equipment on the engine-generator set.Electrical measurements shall be performed in accordance with IEEE Std 120. Definitions of terms are in accordance with IEEE Std 100. Temperature limits in the rating of electrical equipment and for the evaluation of electrical insulations shall be in accordance with IEEE Std 1.

3.5.1.2   Power Factor

For all engine-generator set operating tests the load power factor shall be the power factor specified in the engine-generator set parameter schedule.

3.5.1.3   Contractor Supplied Items

The Contractor shall provide equipment and supplies required for inspections and tests including fuel, test instruments, and loadbanks at the specified power factors.

3.5.1.4   Instruments

Readings of panel gauges, meters, displays, and instruments provided as permanent equipment shall be verified during test runs, using test instruments of greater precision and accuracy. Test instrument accuracy shall be within the following: current plus or minus 1.5%, voltage plus or minus 1.5%, real power plus or minus 1.5%, reactive power plus or minus 1.5%, power factor plus or minus 3%, frequency plus or minus 0.5%. Test instruments shall be calibrated by a recognized standards laboratory within 30 days prior to testing.

3.5.1.5   Sequence

The sequence of testing shall be as specified in the approved testing plan unless variance is authorized by the Contracting Officer. Field testing shall be performed in the presence of the Contracting Officer. Tests may be scheduled and sequenced in order to optimize run-time periods; however, the following general order of testing shall be followed: Construction Tests; Inspections; Pre-operational Tests; Safety Run Tests; Performance Tests; and Final Inspection.

3.5.2   Construction Tests

Individual component and equipment functional tests for fuel piping, coolant piping, and lubricating-oil piping, electrical circuit continuity, insulation resistance, circuit protective devices, and equipment not provided by the engine-generator set manufacturer shall be performed prior to connection to the engine-generator set.

3.5.2.1   Piping Test

a. Lube-oil and fuel-oil piping shall be flushed with the same type of fluid intended to flow through the piping, until the outflowing fluid has no obvious sediment or emulsion.

b. Fuel piping which is external to the engine-generator set shall be tested in accordance with NFPA 30. All remaining piping which is external to the engine-generator set shall be pressure tested with air pressure at 150% of the maximum anticipated working pressure, but not less than 1.03 MPa, for a period of 2 hours to prove the piping has no leaks. If piping is to be insulated, the test shall be performed before the insulation is applied.

3.5.2.2 Electrical Equipment Tests

a. Low-voltage cable insulation integrity tests shall be performed for cables connecting the generator breaker to the automatic transfer switch. Low-voltage cable, complete with splices, shall be tested for insulation resistance after the cables are installed, in their final configuration, ready for connection to the equipment, and prior to energization. The test voltage shall be 500 volts dc, applied for one minute between each conductor and ground and between all possible combinations conductors in the same trench, duct, or cable, with all other conductors in the same trench, duct, or conduit. The minimum value of insulation shall be:

R in megohms = (rated voltage in kV + 1) x 304,800/(length of cable in meters)

R in megohms = (rated voltage in kV + 1) x 1000/(length of cable in feet)

Each cable failing this test shall be repaired or replaced. The repair cable shall be retested until failures have been eliminated.

b. Circuit breakers and switchgear shall be examined and tested in accordance with the manufacturer's published instructions for functional testing.

3.5.3 Inspections

The following inspections shall be performed jointly by the Contracting Officer and the Contractor, after complete installation of each engine-generator set and its associated equipment, and prior to startup of the engine-generator set. Checks applicable to the installation shall be performed. The results of those which are physical inspections (I) shall be documented by the Contractor and submitted in accordance with paragraph SUBMITTALS. The Contractor shall present manufacturer's data for the inspections designated (D) at the time of inspection. Inspections shall verify that equipment type, features, accessibility, installation and condition are in accordance with the contract specification. Manufacturer's statements shall certify provision of features which cannot be verified visually.

1.	Drive belts.	(I)
2.	Governor type and features.	(I)
3.	Engine timing mark.	(I)
4.	Starting motor.	(I)
5.	Starting aids.	(I)
6.	Coolant type and concentration.	(D)
7.	Radiator drains.	(I)

8.	Block coolant drains.	(I)
9.	Coolant fill level.	(I)
10.	Coolant line connections.	(I)
11.	Coolant hoses.	(I)
12.	Combustion air filter.	(I)
13.	Intake air silencer.	(I)
14.	Lube oil type.	(D)
15.	Lube oil sump drain.	(I)
16.	Lube-oil filter.	(I)
17.	Lube-oil level indicator.	(I)
18.	Lube-oil fill level.	(I)
19.	Lube-oil line connections.	(I)
20.	Lube-oil lines.	(I)
21.	Fuel type.	(D)
22.	Fuel-level.	(I)
23.	Fuel-line connections.	(I)
24.	Fuel lines.	(I)
25.	Fuel filter.	(I)
26.	Access for maintenance.	(I)
27.	Voltage regulator.	(I)
28.	Battery-charger connections.	(I)
29.	Wiring & terminations.	(I)
30.	Instrumentation.	(I)
31.	Hazards to personnel.	(I)
32.	Base.	(I)
33.	Nameplates.	(I)
34.	Paint.	(I)
35.	Exhaust-heat system.	(I)
36.	Exhaust muffler.	(I)
37.	Switchboard.	(I)
38.	Switchgear.	(I)
39.	Access provided to controls.	(I)
40.	Enclosure is weather resistant.	(I)
41.	Engine & generator mounting bolts (application).	(I)

3.5.4 Pre-operational Tests

3.5.4.1 Protective Relays

Protective relays shall be visually and mechanically inspected, adjusted, tested, and calibrated in accordance with the manufacturer's published instructions. Tests shall include pick-up, timing, contact action, restraint, and other aspects necessary to ensure proper calibration and operation. Relay settings shall be implemented in accordance with the installation coordination study. Relay contacts shall be manually or electrically operated to verify that the proper breakers and alarms initiate. Relaying current transformers shall be field tested in accordance with IEEE ANSI/IEEE C57.13.1.

3.5.4.2 Insulation Test

Generator and exciter circuits insulation resistance shall be tested in accordance with IEEE Std 43. Stator readings shall be taken at the circuit breaker, to include generator leads to switchboard. Results of insulation resistance tests shall be recorded. Readings shall be within limits specified by the manufacturer. Mechanical operation, insulation resistance, protective relay calibration and operation, and wiring continuity of switchboard assembly shall be verified. Precautions shall be taken to preclude damaging generator components during test.

3.5.4.3 Engine-Generator Connection Coupling Test

When the generator provided is a two-bearing machine, the engine-generator connection coupling shall be inspected and checked by dial indicator to prove that no misalignment has occurred. The dial indicator shall measure variation in radial positioning and axial clearance between the coupling halves. Readings shall be taken at four points, spaced 90 degrees apart. Solid couplings and pin-type flexible couplings shall be aligned within a total indicator reading of 0.012 to 0.025 mm for both parallel and angular misalignment. For gear-type or grid-type couplings, 0.05 mm will be acceptable.

3.5.5 Safety Run Test

For the following tests, if any parts are changed, or adjustments made to the generator set, its controls, or auxiliaries, the associated safety tests shall be repeated.

a. Perform and record engine manufacturer's recommended prestarting checks and inspections.

b. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

c. Activate the manual emergency stop switch and verify that the engine stops.

d. Remove the high and pre-high lubricating oil temperature sensing elements from the engine and temporarily install a temperature gauge in their normal locations on the engine (required for safety, not for recorded data). Where necessary provide temporary wiring harness to connect the sensing elements to their permanent electrical leads.

e. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period. Operate the engine-generator set at no load until the output voltage and frequency stabilize. Monitor the temporarily installed temperature gauges. If either temperature reading exceeds the value required for an alarm condition, activate the manual emergency stop switch.

f. Immerse the elements in a vessel containing controlled-temperature hot oil and record the temperature at which the pre-high alarm activates and the temperature at which the engine shuts down. Remove the temporary temperature gauges and reinstall the temperature sensors on the engine.

g. Remove the high and pre-high coolant temperature sensing elements from the engine and temporarily install a temperature gauge in their normal locations on the engine (required for safety, not for recorded data). Where necessary provide temporary wiring harness to connect the sensing elements to their permanent electrical leads.

h. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period. Operate the engine generator-set at no load until the output voltage and frequency stabilize.

i. Immerse the elements in a vessel containing controlled-temperature hot oil and record the temperature at which the pre-high alarm activates and the temperature at which the engine shuts down. Remove the temporary temperature gauges and reinstall the temperature sensors on the engine.

j. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

k. Operate the engine generator-set for at least 2 hours at 75% of Service Load.

l. Verify proper operation and setpoints of gauges and instruments.

m. Verify proper operation of ancillary equipment.

n. Manually adjust the governor to increase engine speed past the overspeed limit. Record the RPM at which the engine shuts down.

o. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 75% of Service Load.

p. Manually adjust the governor to increase engine speed to within 2% of the overspeed trip speed previously determined and operate at that point for 5 minutes. Manually adjust the governor to the rated frequency.

q. Manually fill the day tank to a level above the overfill limit. Record the level at which the overfill alarm sounds. Verify shutdown of the fuel transfer pump. Drain the day tank down below the overfill limit.

r. Shut down the engine. Remove the time-delay low lube oil pressure alarm bypass and try to start the engine.

s. Attach a manifold to the engine oil system (at the oil pressure sensor port) that contains a shutoff valve in series with a connection for the engine's oil pressure sensor followed by an oil pressure gauge ending with a bleed valve. The engine's oil pressure sensor shall be moved from the engine to the manifold. The manifold shutoff valve shall be open and bleed valve closed.

t. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 75% of Service Load.

u. Close the manifold shutoff valve. Slowly allow the pressure in the manifold to bleed off through the bleed valve while watching the pressure gauge. Record the pressure at which the engine shuts down. Catch oil spillage from the bleed valve in a container. Add the oil from the container back to the engine, remove the manifold, and reinstall the engine's oil pressure sensor on the engine.

v. Start the engine, record the starting time, make and record engine manufacturer's after-starting checks and inspections and operate the engine generator-set for at least 15 minutes at 100% of Service Load. Record the maximum sound level in each frequency band at a distance of 22.9m from the end of the exhaust and air intake piping directly along the path of intake and discharge for horizontal piping; or at a radius of 22.9m from the engine at 45 degrees apart in all directions for vertical piping. If a sound limiting enclosure is not provided, the muffler and air intake silencer shall be modified or replaced as required to meet the sound limitations of this specification. If the sound limitations can not be obtained by modifying or replacing the muffler and air intake silencer, the contractor shall notify the Contracting Officers Representative and provide a recommendation for meeting the sound limitations.

w. Manually drain off fuel slowly from the day tank to empty it to below the low fuel level limit and record the level at which the audible alarm sounds. Add fuel back to the day tank to fill it above low level alarm limits.

3.5.6 Performance Tests

In the following tests, where measurements are to be recorded after stabilization of an engine-generator set parameter (voltage, frequency, current, temperature, etc.), stabilization is considered to have occurred when measurements are maintained within the specified bandwidths or tolerances, for a minimum of four consecutive readings. For the following tests, if any parts are changed, or adjustments made to the generator set, its controls, or auxiliaries, the associated tests shall be repeated.

3.5.6.1 Continuous Engine Load Run Test

Test the engine-generator set and ancillary systems at service load to demonstrate durability; verify that heat of extended operation does not adversely affect or cause failure in any part of the system; and check all parts of the system. If the engine load run test is interrupted for any reason, the entire test shall be repeated. The engine load run test shall be accomplished principally during daylight hours, with an average ambient temperature of 34.4 degrees C. , during the month of August. After each change in load in the following test, measure the vibration at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Verify that the vibration is within the allowable range. Data taken at 15 minute intervals shall include the following:

Electrical: Output amperes, voltage, real and reactive power, power factor, frequency.

Pressure: Lube-oil.

Temperature: Coolant.
Lube-oil.
Exhaust.
Ambient.

a. Perform and record engine manufacturer's recommended prestarting checks and inspections. Include as a minimum checking of coolant fluid, fuel, and lube-oil levels.

b. Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warmup period.

c. Operate the engine generator-set for 2 hours at 75% of Service Load.

d. Increase load to 100% of Service Load and operate the engine generator-set for 4 hours.

e. For prime rated units, increase load to 110% of Service Load and operate the engine generator-set for 2 hours.

f. Decrease load to 100% of Service Load and operate the engine generator-set for 2 hours or until all temperatures have stabilized.

g. Remove load from the engine-generator set.

3.5.6.2 Voltage and Frequency Droop Test

For the following steps, verify that the output voltage and frequency return to and stabilize within the specified bandwidth values following each load change. Record the generator output frequency and line-line and line-neutral voltages following each load change.

a. With the generator operating at no load, adjust voltage and frequency to rated voltage and frequency.

b. Increase load to 100% of Rated Output Capacity. Record the generator output frequency and line-line and line-neutral voltages.

c. Calculate the percent droop for voltage and frequency with the following equations.

$$\text{Voltage droop \%} = \frac{\text{No-load volts - rated output capacity volts}}{\text{Rated output capacity volts}} \times 100$$

$$\text{Frequency droop \%} = \frac{\text{No load hertz - rated output capacity hertz}}{\text{Rated output capacity volts}} \times 100$$

d. Repeat steps a. through c. two additional times without making any adjustments.

3.5.6.3 Voltage Regulator Range Test

a. While operating at no load, verify that the voltage regulator adjusts from 90% to 110% of rated voltage.

b. Increase load to 100% of Rated Output Capacity. Verify that the voltage regulator adjusts from 90% to 110% of rated voltage.

3.5.6.4 Governor Adjustment Range Test

a. While operating at no load, verify that the governor adjusts from 90% to 110% of rated frequency.

b. Increase load to 100% of Rated Output Capacity. Verify that the governor adjusts from 90% to 110% of rated frequency.

3.5.6.5 Frequency and Voltage Stability and Transient Response

Verify that the engine-generator set responds to addition and dropping of blocks of load in accordance with the transient response requirements. Document maximum voltage and frequency variation from bandwidth and verify that voltage and frequency return to and stabilize within the specified bandwidth, within the specified response time period. Document results in tabular form and with high resolution, high speed strip chart recorders or comparable digital recorders, as approved by the Contracting Officer. Tabular data shall include the following:

(1.) Ambient temperature (at 15 minute intervals).

(2.) Generator output current (before and after load changes).

(3.) Generator output voltage (before and after load changes).

(4.) Frequency (before and after load changes).

(5.) Generator output power (before and after load changes.

(6.) Graphic representations shall include the actual instrument trace of voltage and frequency showing:

Charts marked at start of test; observed steady-state band; mean of observed band; momentary overshoot and undershoot (generator terminal voltage and frequency) and recovery time for each load change together with the voltage and frequency maximum and minimum trace excursions for each steady state load condition prior to and immediately following each load change. Generator terminal voltage and frequency transient recovery time for each step load increase and decrease.

a. Perform and record engine manufacturer's recommended prestarting checks and inspections.

b. Start the engine, make and record engine manufacturer's after-starting checks and inspections during a reasonable warm-up period and no load. Verify stabilization of voltage and frequency within specified bandwidths.

c. With the unit at no load, apply the Maximum Step Load Increase.

d. Apply load in steps equal to the Maximum Step Load Increase until the addition of one more step increase will exceed the Service Load.

e. Decrease load to the unit such that addition of the Maximum Step Load Increase will load the unit to 100% of Service Load.

f. Apply the Maximum Step Load Increase.

g. Decrease load to zero percent in steps equal to the Maximum Step Load Decrease.

h. Repeat steps c. through g.

3.5.7 Automatic Operation Tests for Stand-Alone Operation

The automatic loading system shall be tested to demonstrate automatic starting, and loading and unloading of the engine-generator set. The loads for this test shall utilize the actual loads to be served, and the loading sequence shall be the indicated sequence. Perform this test for a minimum of two successive, successful tests. Data taken shall include the following:

(1.) Ambient temperature (at 15 minute intervals).

(2.) Generator output current (before and after load changes).

(3.) Generator output voltage (before and after load changes).

(4.) Generator output frequency (before and after load changes).

a. Initiate loss of the primary power source and verify automatic sequence of operation.

b. Restore the primary power source and verify sequence of operation.

c. Verify resetting of controls to normal.

3.5.8 Fuel Consumption Tests

Fuel consumption tests to confirm the manufacturer's certified rates shall be performed on engine generator set and the results tabulated and averaged. Fuel consumption tests shall be conducted under the direct supervision of the engine manufacturer's representative. Fuel consumption readings shall be taken at 15 minute intervals, over a minimum period of 1 hour at 50% Service Load, 1 hour at 75% Service Load, and 4 hours at 100% Service Load. Fuel consumption data may be taken during the 75% load test and 100% load tests. Fuel consumption readings at site conditions shall be correlated to the guarantee-baseline conditions. Test report shall contain: readings of the output frequency, voltage, current, power factor, and power; barometric pressure; ambient temperature; intake-air temperature; fuel temperature; the site fuel consumption readings, adjustment calculations, factors, and source references for correlation of actual consumption rate of the guaranteed rate.

a. Start and operate the generator set and allow it to stabilize at rated load, rated voltage and rated frequency. During this period, readings of all instruments including thermal instrumentation shall be recorded at minimum intervals of 10 minutes. If necessary, adjustments to the load, voltage and frequency may be made to maintain rated load at rated voltage and rated frequency. However, adjustments to the voltage and frequency shall be limited to those adjustments available to the operator, specifically adjustments to the voltage or frequency adjust devices. On generator sets utilizing a droop-type speed control system as the prime speed control, the speed and droop portions of the control may be adjusted. No other adjustments to the voltage and frequency control systems shall be made unless permitted by the procurement document. Adjustments to the load, voltage or frequency controls shall be recorded on the data sheet. Unless otherwise specified in the procurement document, stabilization will be consideration to have occurred when four consecutive voltage and current recorded readings of the generator (or exciter) field either remain unchanged or have only minor variations about an equilibrium condition with no evident continued increase or decrease in value after the last adjustment to the load, voltage or frequency has been made.

b. Perform one of the following procedures:

BALANCE SCALE PROCEDURE.

(1.) Supply fuel from auxiliary container mounted on a balance scale.

(2.) After stabilization has occurred, set the balance weights at any convenient value slightly less than the total weight of the fuel and container.

(3.) Start the stopwatch when the balance weights fall and record the total weight.

(4.) Reduce the balance weight a convenient amount and record the amount of the weights removed.

(5.) Stop the stopwatch when the balance weights fall and record the total weight and the elapsed time.

(6.) Repeat steps (1) thru (2) above until the timed portion of the test exceeds the 2 hours.

(7.) >From the total elapsed time and total of the weights removed calculate the fuel consumption in terms of pounds per hour.

(8.) Using the value obtained in step (7) above, compute the rate of fuel consumption per kilowatt hour, as follows:

$$\text{Pounds per kWH} = \frac{\text{Fuel Consumption in Pounds per Hour}}{\text{kW Load}}$$

(9.) Repeat the test for each load condition specified.

(10.) Determine the capacity of the generator set fuel tank in pounds of fuel.

(11.) For each specified load, compute the number of continuous hours the generator set will operate on a full tank of fuel. The following formula shall be used.

$$\text{Operating hours} = \frac{\text{Fuel Tank Capacity (Pounds)}}{\text{Fuel Consumption (Pounds per hour)}}$$

ALTERNATE PROCEDURE FOR WEIGHING FUEL

(1.) Supply fuel from the auxiliary fuel container, mounted on a platform balance, or other weighing device.

(2.) After stabilization has occurred, record weight readings every one-half hour for a period of 2 hours.

(3.) Calculate the average hourly fuel consumption rate in pounds per hour.

(4.) Using the average hourly fuel consumption rate obtained above, compute the rate of fuel consumption per kilowatt hour, as follows:

$$\text{Pounds per kWH} = \frac{\text{Fuel Consumption}}{\text{kW Load}}$$

(5.) Repeat test for each load condition specified.

(6.) Determine the capacity of the generator set fuel tank in pounds of fuel.

(7.) for each specified load test, compute the number of continuous ours the generator set will operate on a full tank of fuel. The following formula shall be used:

$$\text{Operating Hours} = \frac{\text{Fuel Tank Capacity (Pounds)}}{\text{Fuel Consumption (Pounds per Hour)}}$$

ALTERNATE PROCEDURE USING FLOWMETER.

Flowmeters may be used to determine the fuel rate. They usually are calibrated in either gallons per hour, or pounds per hour, for a fuel of a definite specific gravity and temperature.

(1.) After stabilization has occurred record the fuel consumption rate, and continue to record the fuel consumption rate at one-half hour intervals for 2 hours.

(2.) Determine the average of the readings (correct for fuel specific gravity and temperature). This is the fuel consumption rate and should be converted, if necessary, to pounds per hour.

(3.) Using the average value obtained above, calculate the rate of fuel consumption per kilowatt hour.

(4.) Repeat the test for each load condition specified.

(5.) Determine the capacity of the generator set fuel tank in pounds of fuel.

(6.) For each specified load test, compute the number of continuous hours the generator set will operate on a full tank of fuel. The following formula shall be used:

$$\text{Operating Hours} = \frac{\text{Fuel Tank Capacity (Pounds)}}{\text{Fuel Consumption (Pounds per Hour)}}$$

c. Results. Compare the operating hours or the fuel consumption rate per kWH.

3.5.9 Final Testing and Inspection

a. Start the engine, record the starting time, make and record all engine manufacturer's after-starting checks and inspections during a reasonable warm-up period.

b. Increase the load in steps no greater than the Maximum Step Load Increase to 100% of Service Load, and operate the engine-generator set for at least 30 minutes. Measure the vibration at the end bearings (front and back of engine, outboard end of generator) in the horizontal, vertical, and axial directions. Verify that the vibration is within the same range as previous measurements and is within the required range.

c. Remove load and shut down the engine-generator set after the recommended cool down period.

d. Remove the lube oil filter and have the oil and filter examined by the engine manufacturer for excessive metal, abrasive foreign particles, etc. Any corrective action shall be verified for effectiveness by running the engine for 8 hours at Service Load, then re-examining the oil and filter.

e. Remove the fuel filter and examine the filter for trash, abrasive foreign particles, etc.

f. Visually inspect and check engine and generator mounting bolts for tightness and visible damage.

g. Replace air, oil, and fuel filters with new filters.

3.6 POSTED DATA AND INSTRUCTIONS

Posted Data and Instructions shall be posted prior to field acceptance testing of the engine generator set. Two sets of instructions/data shall be typed in 8 1/2" x 11" format, laminated in weatherproof plastic, and placed in three-ring vinyl binders. The binders shall be placed as directed by the Contracting Officer. The instructions shall be in place prior to acceptance of the engine generator set installation. First set shall include a one-line diagram, wiring and control diagrams and a complete layout of the system. Second set shall include the condensed operating instructions describing manufacturer's pre-start checklist and precautions; startup procedures for test-mode, manual-start mode, and automatic-start mode (as applicable); running checks, procedures, and precautions; and shutdown procedures, checks, and precautions. Instructions shall include procedures for interrelated equipment (such as heat recovery systems, co-generation, load-shedding, and automatic transfer switches).

3.7 ONSITE TRAINING

The Contractor shall conduct training course for operating staff as designated by the Contracting Officer. The training period shall consist of a total 16 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance. All operation and maintenance manuals shall bee approved and made available for the training course. All posted instructions shall be approved and posted prior to the beginning date of the training course. The training course schedule shall be coordinated with the Using Service's work schedule, and submitted for approval 14 days prior to beginning date of proposed beginning date of training. The course instructions shall cover pertinent points involved in operating, starting, stopping, servicing the equipment, as well as major elements of the operation and maintenance manuals. Additionally, the course instructions shall demonstrate routine maintenance procedures as described in the operation and maintenance manuals. Two copies of a video tape of the entire training session and manufacturers operating and maintenance training course shall be submitted.

3.8 ACCEPTANCE

Final acceptance of the engine-generator set will not be given until the contractor has successfully completed all tests and all defects in installation material or operation have been corrected.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 16 - ELECTRICAL

SECTION 16265

UNINTERRUPTIBLE POWER SUPPLY (UPS) 130 KVA CAPACITY

09/98

-- End of Section Table of Contents --

SECTION 16265

UNINTERRUPTIBLE POWER SUPPLY (UPS) 130 KVA CAPACITY
09/98

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B 173	(1995) Rope-Lay-Stranded Copper Conductors Having Concentric-Stranded Members, For Electrical Conductors

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE ANSI/IEEE C57.110	(1998) Establishing Transformer Capability When Supplying Nonsinusoidal Load Currents
IEEE C62.41	(1991; R 1995) Surge Voltages in Low-Voltage AC Power Circuits
IEEE Std 450	(1995) Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications
IEEE Std 485	(1997) Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

NEMA PE 1	(1992) Uninterruptible Power Systems

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1999) National Electrical Code

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

*8

SD-02 Shop Drawings

UPS System; G, RE~~AE~~
Installation; G, RE~~AE~~

Detail drawings consisting of a complete list of equipment and materials, manufacturer's descriptive and technical literature, battery sizing calculations per IEEE Std 485, installation instructions, single-line diagrams, ladder-type schematic diagrams, elevations, layout drawings, and details required to demonstrate that the system has been coordinated and will function properly as a unit.

SD-03 Product Data

Performance Requirements; G, RE~~AE~~

Pertinent performance data for the UPS system, using a copy of the data sheets supplied with this specification. Data sheets shall be certified by a responsible officer of the UPS manufacturer.

Spare Parts; G, RE

Spare parts data for each different item of material and equipment specified, not later than the date of beneficial occupancy. The data shall include a complete list of parts and supplies with current unit prices and source of supply and an itemized price breakdown of spare parts recommended for stocking. The recommended spare parts selected shall be those which, in the manufacturer's judgment, will be involved in the majority of maintenance difficulties encountered.

Field Training; G, RE

Lesson plans and training manuals for the training phases, including type of training to be provided and proposed dates, with a list of reference materials.

SD-06 Test Reports

Factory Testing; G, RE
Field Supervision, Startup and Testing; G, RE

A detailed description of proposed factory test and field test procedures, including proposed dates and steps outlining each test, how it is to be performed, what it accomplishes, and its duration, not later than one month prior to the date of each test.

Factory and field test reports in booklet form tabulating factory and field tests and measurements performed, upon completion and testing of the installed system. Factory and field test reports shall be signed by an official authorized to certify on behalf of the manufacturer of the UPS system that the system meets specified requirements. The reports shall be dated after the award of this contract, shall state the Contractor's name and address, shall name the project and location, and shall list the specific requirements which are being certified.

1.3   SYSTEM DESCRIPTION

The UPS system shall consist of UPS module, battery system, battery protective device, system cabinet, static bypass transfer switch, controls and monitoring transformers and switchboard. Input ac power shall be connected to the normal source ac input of the UPS module. The battery shall be connected to the dc input of the UPS module through the battery protective device. The ac output of the UPS system shall be connected to the critical loads.

1.3.1 UPS Module and Battery System

UPS module shall contain required output isolation transformer, rectifier/charger unit, inverter unit and controls, battery protective device, and any other specified equipment/devices. Battery system shall contain the battery cells, racks, battery disconnect, battery monitor and cabinet, if required.

1.3.2 Cabinet, Static Bypass Transfer Switch, Control and Monitoring

The UPS system shall include the system cabinet, static bypass transfer switch, system protective devices, monitoring and controls, means of isolating the system from the critical load, and remote monitoring interfaces.

1.3.3 Design Requirements

1.3.3.1 Parts and Materials

Parts and materials comprising the UPS system shall be new, of current manufacture, of a high grade and free of defects and imperfections, and shall not have been in prior service except as required during aging and factory testing.

1.3.3.2 Components

Active electronic devices shall be solid state. Semiconductor devices shall be sealed. Relays shall be dust-tight.

1.3.3.3 Semiconductor Fusing

Power semiconductors shall be fused to prevent cascaded or sequential semiconductor failures. Indicator lamp denoting blown fuse conditions shall be readily observable by the operator without removing panels or opening cabinet doors.

1.3.3.4 Interchangeability

The subassemblies in one UPS module shall be interchangeable with the corresponding modules within the same UPS, and from one UPS system to another of identical systems.

1.3.3.5 Control Power

Control power shall be derived from two sources, input and output, with automatic selective control. The control power circuit shall have suitable protection, appropriately marked and located in the immediate vicinity of the input protective device.

1.3.3.6 EMI/RFI Protection

The components and the system shall be designed to minimize the emission of electromagnetic waves that may cause interference with other equipment.

1.3.3.7 Wiring

Wiring practices, materials, and coding shall be in accordance with the requirements of NFPA 70 and other applicable standards. Wire runs shall be protected in a manner which separates power and control wiring. Control wiring shall be minimum No. 16 AWG extra-flexible stranded copper. Logic-circuit wiring may be smaller. Ribbon cables shall be minimum No. 22 AWG. Control wiring shall have permanently attached wire numbers.

1.3.3.8 Terminations

Terminals shall be supplied for making power and control connections. Terminal blocks shall be provided for field wiring terminals. Terminal blocks shall be heavy-duty, strap-screw type. Terminal blocks for field wiring shall be located in one place in each module and in the system cabinet. Control wiring shall be extended to the terminal block location. No more than two wires shall land on any terminal point. Where control wiring is attached to the same point as power wiring, a separate terminal shall be provided. If bus duct is used, bus stubs shall be provided where bus duct enters cabinets.

1.3.3.9 Internal Assembly

The subassemblies shall be mounted in pull-out and/or swing-out trays where feasible. Cable connections to the trays shall be sufficiently long to allow easy access to all components. Where not feasible to mount subassemblies in pull-out or swing-out trays, they shall be firmly mounted inside the enclosure. Test points or logic indicators shall be labeled and located on the front edge of the control logic cards, if used.

1.3.3.10 Cabinet Structure

UPS system shall be installed in cabinets of heavy-duty structure meeting the NEMA PE 1 standards for floor mounting. UPS module cabinet shall be structurally adequate for forklift handling or lifting. Removable lifting eyes shall be provided on top of each cabinet. UPS module cabinet shall have hinged and lockable doors on the front only, with assemblies and components accessible from the front. Doors shall be key lockable. Operating controls shall be located outside the locked doors. Input, output, and battery cables shall be installed through the top or bottom of the cabinet.

1.3.3.11 Cabinet Finish

Equipment cabinet shall be cleaned, primed and painted in the manufacturer's standard colors, in accordance with accepted industry standards.

1.3.3.12 Mimic Bus

If painted, mimic bus and other front-panel markings (such as those showing circuit breakers or switches and fuses) shall be painted with durable acrylic-based paint.

1.3.3.13 Live Parts (300 Volts and Above)

Live parts (300 volts and above) that are exposed when front access doors are open shall be adequately protected or covered to minimize the chance of accidental contact.

1.3.3.14 Drawout Assemblies

Drawout assemblies weighing 23 kg or more shall be provided with a means of lifting, either an overhead device or a hoisting device.

1.3.3.15 Safety

UPS shall be equipped with instruction plates including warnings and cautions, suitably located, describing any special or important procedures to be followed in operating and servicing the equipment.

1.3.4 Performance Requirements

1.3.4.1 Normal Operation

The UPS module rectifier/charger shall convert the incoming ac input power to dc power for the inverter and for float charging the battery. The inverter shall supply ac power continuously. Inverter output shall be synchronized with the bypass ac power source, provided that the bypass ac power source is within the specified frequency range. The UPS system shall supply ac power to the critical loads.

1.3.4.2 Loss of ac Input Power

The battery shall supply dc power to the inverter so that there is no interruption of ac power to the critical load whenever the ac input power source deviates from the specified tolerances or fails completely. The battery shall continue to supply power to the inverter for the specified protection time. At the same time, an alarm shall sound to alert operating personnel, allowing startup of a secondary power source or orderly shutdown of the critical load.

1.3.4.3 Return of ac Input Power Source

The rectifier/charger shall start and assume the dc load from the battery when the ac input power source returns. The rectifier/charger shall then simultaneously supply the inverter with dc power and recharge the battery. This shall be an automatic function and shall cause no disturbance to the critical load.

1.3.4.4 Failure of ac Input Power to Return

Should the ac input power fail to return before the battery voltage reaches the discharge limit, the UPS system shall disconnect from the critical load to safeguard the battery.

1.3.4.5 Transfer to Bypass ac Power Source

When the static bypass switch senses an overload, two or more inverter shutdown signals, or degradation of the inverter output, the bypass switch shall automatically transfer the critical load from the inverter output to the bypass ac power source without an interruption of power only if the connected load exceeds the capacity of the remaining on-line modules. If the bypass ac power source is out of normal tolerance limits, the UPS and the critical load shall shut down.

1.3.4.6 Retransfer to Inverter

The static bypass switch shall be capable of automatically retransferring the load back to the inverter output after the inverter output has returned to normal conditions. Retransfer shall not occur if the two sources are not synchronized.

1.3.4.7 UPS Module Maintenance

UPS modules shall be capable of manual disconnection from the critical load bus for maintenance without disturbing the critical load bus.

1.3.4.8 UPS System Maintenance

Manual closure of the maintenance bypass switch shall transfer the critical load from the inverter output to the bypass ac power source without disturbing the critical load bus. UPS module shall be capable of manual return to normal operation after completion of maintenance.

1.3.4.9 Battery Maintenance

The battery protective device shall provide the means of disconnecting the battery from the rectifier/charger and inverter for maintenance. The UPS module shall continue to function and meet the performance criteria specified except for the battery function.

1.4 QUALITY ASSURANCE

1.4.1 Reliability

UPS shall have a minimum acceptable system Mean Time Between Failures (MTBF) of 8 hours. A failure is defined as any interruption to or degradation of the UPS output. Automatic switching to bypass due to a problem with the UPS system does not constitute a failure, provided that the critical load is not disturbed.

1.4.2 Maintainability

UPS shall have a maximum acceptable system Mean Time To Repair (MTTR) of 30 minutes. Repair time is defined as the clock time from the arrival of the service technician to the time when the UPS is restored to service either by repair or substitution of the failed component.

1.5 DELIVERY AND STORAGE

Equipment placed in storage shall be protected from humidity and temperature variations, dirt, dust, or other contaminants.

1.6 PROJECT/SITE CONDITIONS

1.6.1 Environmental Conditions

The UPS and battery system shall be capable of withstanding any combination of the following external environmental conditions without mechanical or electrical damage or degradation of operating characteristics.

a. Operating altitude: Sea level to 1,200 meters (4,000 ft.) (Systems applied at higher altitudes shall be derated in accordance with the manufacturer's instructions).

b. Non-operating altitude: Sea level to 12,000 meters (40,000 ft.)

c. Operating ambient temperature range: 0 to 40 degrees C.

d. Non-operating and storage ambient temperature range: Minus 20 to plus 60 degrees C.

e. Operating relative humidity: 0 to 95 percent, without condensation.

1.6.2 Sound Pressure Levels

Sound pressure levels produced by the UPS, when operating under full rated load, at a distance of 5 feet in any direction from the perimeter of the unit, shall not exceed 75dB as measured on the A scale of a standard sound level meter at slow response.

1.6.3 Verification of Dimensions

The Contractor shall become familiar with details of the work, verify dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing the work.

1.7 NAME PLATES

Each major item of equipment shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment.

1.8 SPECIAL TOOLS

One set of special tools, calibration devices, and instruments required for operation, calibration, and maintenance of the equipment shall be provided.

1.9 OPERATION AND MAINTENANCE MANUALS

Six complete copies of operation manuals for the UPS System outlining the step-by-step procedures required for system startup, operation and shutdown shall be provided. The instructions shall include the manufacturer's name, equipment model number, service manual, parts list, and brief description of equipment and its basic operational features. Six complete copies of maintenance manuals listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides shall be provided. Corrective maintenance procedures shall identify the most probable failures and the appropriate repairs. Test measurement levels shall be referenced to specific test points on the installed equipment. Operation and maintenance manuals may be either combined or separate.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Materials and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of such products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.2 LOAD PROFILE

The UPS system shall be compatible with the load characteristics defined in the LOAD PROFILE TABLE below and load configuration shown. Compensation for UPS/load interaction problems resulting from nonlinear loads or transformer and motor inrush shall be provided.

LOAD PROFILE TABLE

Type of load: Non-Linear (Data Processing.

Size of load: 130 kVA.

Switching pattern: Cycled Daily.

Transient characteristics: 15 times steady state rms current for 1/4 cycle for electric discharge lighting.

Steady-state characteristics: 0.9.

2.3 UPS SYSTEM RATINGS

Unless stated otherwise, the parameters listed are under full output load at 0.9 power factor, with batteries fully charged and floating on the dc bus and with nominal input voltage.

2.3.1 System Capacity

Overall 130 kVA, 117 kW, non redundant, at 40 degrees C.

2.3.2 Module Capacity

130 kVA, 117 kW.

2.3.3 Battery Capacity

Discharge time to end voltage: 5 minutes, at 25 degrees C. Battery shall be capable of delivering 125 percent of full rated UPS load at initial start-up.

2.3.4 Static Switch

200 amperes, 65,000 amperes symmetrical interrupting capacity.

2.3.5 System Bus Bracing

Braced for 65,000 amperes symmetrical interrupting capacity.

2.3.6 ac Input

a. Voltage 480 volts line-to-line.

b. Number of phases: 3-phase, 3-wire, plus ground.

c. Voltage Range: Plus 10 percent, minus 15 percent, without affecting battery float voltage or output voltage.

d. Frequency: 60 Hz, plus or minus 5 percent.

e. Power walk-in: 20 percent to 100 percent over 15 to 24 seconds.

f. Total harmonic current distortion (THD) reflected into the primary line: 10 percent maximum.

g. Transformer sub-cycle inrush: 4 to 8 times full load rating.

2.3.7 ac Output

a. Voltage 208 volts line-to-line, 120 volts line-to-neutral.

b. Number of phases: 3-phase, 4-wire, plus ground.

c. Voltage regulation:

(1) Balanced load: Plus or minus 1.0 percent.

(2) 50 percent load imbalance, phase-to-phase: Plus or minus 2 percent.

(3) No-load voltage modulation: Plus or minus 1 percent.

(4) Voltage drift: Plus or minus 1 percent over any 30 day interval (or length of test) at stated ambient conditions.

d. Voltage adjustment: Plus or minus 5 percent manually.

e. Frequency: 60 Hz.

f. Frequency regulation: Plus or minus 0.1 percent.

g. Frequency drift: Plus or minus 0.1 percent over any 24 hour interval (or length of test) at stated ambient conditions when on internal oscillator.

h. Harmonic content (RMS voltage): 3 percent single harmonic, maximum; 5 percent total maximum with linear load. Voltage THD shall be less than 7 percent with up to 50 percent nonlinear load and a crest factor of less than 3 to 1.

i. Load power factor operating range: 1.0 to 0.8 lagging.

j. Phase displacement:

(1) Balanced load: Plus or minus 1 degree of bypass input.

(2) 50 percent load imbalance phase-to-phase: Plus or minus 3 degrees of bypass input.

k. Wave-form deviation factor: 5 percent at no load.

l. Overload capability (at full voltage) (excluding battery):

(1) 125 percent load for 10 minutes.

(2) 150 percent load for 30 seconds.

(3) 300 percent load for one cycle after which it shall be current limited to 150 percent until fault is cleared or UPS goes

to bypass.

2.3.8 Transient Response

2.3.8.1 Voltage Transients

a. 50 percent load step/0 percent to 50 percent load: Plus or minus 8 percent.

b. 50 percent load step/50 percent to 100 percent load: Plus or minus 8 percent.

c. Loss or return of ac input: Plus or minus 1 percent.

d. Loss or return of redundant module:

(1) Manually: Plus or minus 8 percent.

(2) Automatically: Plus or minus 8 percent.

e. Automatic transfer of load from UPS to bypass: Plus or minus 4 percent.

f. Manual retransfer of load from bypass to UPS: Plus or minus 4 percent.

g. Response time: Recovery to 99 percent steady-state condition within 50 milliseconds after any of the above transients.

2.3.8.2 Frequency

a. Transients: Plus or minus 0.5 Hz maximum.

b. Slew Rate: 1.0 Hz maximum per second.

2.3.9 Efficiency

a. Minimum Single-Module Efficiency: 90 percent at full load kW.

b. Minimum System Efficiency: 89 percent at full system load kW.

2.4 UPS MODULE

2.4.1 General Description

UPS module shall consist of a rectifier/charger unit and a 3-phase inverter unit with their associated transformers, synchronizing equipment, protective devices and accessories as required for operation.

2.4.2 Rectifier/Charger Unit

Rectifier/charger unit shall be solid state and shall provide direct current to the dc bus.

2.4.2.1 Input Protective Device

Rectifier/charger unit shall be provided with an input protective device. The protective device shall be sized to accept simultaneously the full-rated load and the battery recharge current. The protective device shall be capable of shunt tripping and shall have 65,000 amperes symmetrical interrupting capacity. The protective device shall have provision for locking in the "off" position. A surge suppression device shall be installed at the UPS input to protect against lightning and switching surges.

2.4.2.2 Power Transformer

A dry-type, isolated-winding power transformer shall be used for the rectifier unit. The transformer's hottest spot winding temperature shall not exceed the temperature limit of the transformer insulation material when operating at full load. The transformer insulation shall be Class H, 150 degrees C rise. Transformer connections shall be accessible from the front.

2.4.2.3 Power Walk-In

Rectifier/charger unit shall be protected by a power walk-in feature such that when ac power is returned to the ac input bus, the total initial power requirement will not exceed 20 percent of the rated full load current. This demand shall increase gradually to 100 percent of the rated full load current plus the battery charging current over the specified time interval.

2.4.2.4 Sizing

Rectifier/charger unit shall be sized for the following two simultaneous operating conditions:

a. Supplying the full rated load current to the inverter.

b. Recharging a fully-discharged battery to 95 percent of rated ampere-hour capacity within ten times the discharge time after normal ac power is restored, with the input protective device closed.

2.4.2.5 Battery Charging Current

a. Primary current limiting: Battery-charging current shall be voltage regulated and current limited. The battery-charging current limit shall be separately adjustable from 2 percent to 25 percent of the maximum discharge current. After the battery is recharged, the rectifier/charger unit shall maintain the battery at full float charge until the next operation under input power failure. Battery charger shall be capable of providing equalizing charge to the battery.

b. Second step current limiting: The rectifier/charger unit shall also have a second-step battery current limit. This second-step current limit shall sense actual battery current and reduce the input power demand for battery recharging to 50 percent (adjustable from 30 percent to 70 percent) of the normal rate without affecting the system's ability to supply full-rated power to the connected load. The second-step current-limit circuit shall be activated by a dry contact signal from the generator set controls and shall prevent normal rate battery recharging until utility power is restored.

2.4.2.6 Output Filter

Rectifier/charger unit shall have an output filter to minimize ripple current supplied to the battery; the ripple current into the battery shall not exceed 3 percent RMS.

2.4.2.7   dc Voltage Adjustment

Rectifier/charger unit shall have manual means for adjusting dc voltage for battery equalization, to provide voltage within plus 10 percent of nominal float voltage.

2.4.2.8   Battery Isolation Protective Device

Module shall have a dc protective device to isolate the module from the battery system. The protective device size and interrupting rating shall be as required by system capacity and shall incorporate a shunt trip as required by circuit design. The protective device shall have provision for locking in the "off" position.

2.4.3   Inverter Unit

Inverter unit shall be a solid-state device capable of accepting power from the dc bus and providing ac power within specified limits.

2.4.3.1   Output Overload

The inverter shall be able to sustain an overload as specified across its output terminals. The inverter shall not shut off, but shall continue to operate within rated parameters, with inverse-time overload shutdown protection.

2.4.3.2   Synchronism

The inverter shall normally operate in phase-lock and synchronism with the bypass source. Should the bypass source frequency deviate beyond 60 Hz by more than 0.5 Hz, the internal frequency oscillators contained in the power module shall be used to derive the new frequency reference. Upon restoration of the bypass source within the required tolerance, the inverter shall resynchronize with that source at a slew rate not exceeding the specified rate. The oscillator shall be temperature compensated and shall be manually adjustable. The design of the oscillator and synchronizing circuits shall be such that failure of any associated component, connector pin, terminal lead wire or dc power source in either the open or shorted mode shall affect only one inverter leg. Such failure shall not cause transient disturbance of the critical load in excess of the stated limits.

2.4.3.3   Phase Balance

Electronic controls shall be incorporated to provide individual phase voltage compensation to obtain phase balance.

2.4.3.4   Modular Construction

Each control logic printed circuit board shall be electrically and physically packaged on an individual plug-in module with separate indication and adjustments.

2.4.3.5   Output Protective Device

The output protective device shall be capable of shunt tripping and shall have interrupting capacity as specified. Protective device shall have provision for locking in the "off" position.

2.4.3.6   Output Transformer

The inverter output transformer shall be similar to the input transformer and shall be capable of handling up to K-13 nonlinear loads as described in IEEE ANSI/IEEE C57.110.

2.4.3.7   Modular Inverter Isolation

Each inverter in the UPS system shall have fault sensing and static isolation as well as an output protective device, to remove a faulted module from the system without affecting the critical load bus beyond the stated limits.

2.4.4   External Protection

UPS module shall have built-in self-protection against undervoltage, overvoltage, overcurrent and surges introduced on the ac input source and/or the bypass source. The UPS system shall sustain input surges without damage in accordance with IEEE C62.41. The UPS shall also have built-in self-protection against overvoltage and voltage surges introduced at the output terminals by paralleled sources, load switching, or circuit breaker operation in the critical load distribution system.

2.4.5   Internal Protection

UPS module shall be self-protected against overcurrent, sudden changes in output load and short circuits at the output terminals. UPS module shall be provided with output reverse power detection which shall cause that module to be disconnected from the critical load bus when output reverse power is present. UPS module shall have built-in protection against permanent damage to itself and the connected load for predictable types of failure within itself and the connected load. At the end of battery discharge limit, the module shall shut down without damage to internal components.

2.5   STATIC BYPASS TRANSFER SWITCH

A static bypass transfer switch shall be provided as an integral part of the UPS and shall consist of a static switch and a bypass protective device or bypass switch. The control logic shall contain an automatic transfer circuit that senses the status of the inverter logic signals and alarm conditions and provides an uninterrupted transfer of the load to the bypass ac power source, without exceeding the transient limits specified herein, when a malfunction occurs in the UPS or when an external overload condition occurs. The power section of the static bypass transfer switch shall be provided as a plug-in type assembly to facilitate maintenance. The static bypass transfer switch shall be used to connect the bypass ac power source or the UPS inverter output to the critical load when required, and shall have the following features:

2.5.1   Uninterrupted Transfer

The static bypass transfer switch shall automatically cause the bypass ac power source to assume the critical load without interruption when the bypass control logic senses one of the following conditions and the UPS inverter output is synchronized to the bypass ac power source:

a. Inverter overload exceeds unit's rating.

b. Battery protection period is expired and bypass is available.

c. Inverter failure.

2.5.2 Interrupted Transfer

If an overload occurs and the UPS inverter output is not synchronized to the bypass ac power source, the UPS inverter output shall current-limit for 200 milliseconds minimum. The inverter shall then turn off and an interrupted transfer to the bypass ac power source shall be made. If the bypass ac power source is beyond the conditions stated below, an interrupted transfer shall be made upon detection of a fault condition:

a. Bypass voltage greater than plus or minus 10 percent from the UPS rated output voltage.

b. Bypass frequency greater than plus or minus 0.5 Hz from the UPS rated output frequency.

c. Phase differential of ac bypass voltage to UPS output voltage greater than plus or minus 3 degrees.

2.5.3 Manual Transfer

It shall be possible to make a manually-initiated static transfer from the system status and control panel by turning the UPS inverter off.

2.5.4 Automatic Uninterrupted Forward Transfer

The static bypass transfer switch shall automatically forward transfer, without interruption after the UPS inverter is turned "on", or after an instantaneous overload-induced reverse transfer has occurred and the load current has returned to less than the unit's 100 percent rating.

2.5.5 Forced Transfer

The control logic circuitry shall provide the means of making a forced or reverse transfer of the static bypass transfer switch on an interrupted basis. Minimum interruption shall be 200 milliseconds when the UPS inverter is not synchronized to the bypass ac power source.

2.5.6 Overload Ratings

The static bypass transfer switch shall withstand the following overload conditions:

a. 2000 percent of UPS output rating for two cycles.

b. 200 percent of UPS output rating for 5 minutes.

c. 125 percent of UPS output rating for 10 minutes.

2.5.7 Static Switch Disconnect

A static switch disconnect shall be incorporated to isolate the static bypass transfer switch assembly so it can be removed for servicing. The switch shall be equipped with auxiliary contacts and provision for padlocking in either the "on" or "off" position.

2.6 MAINTENANCE BYPASS SWITCH

2.6.1 General

A maintenance bypass switch shall be provided as an integral part of the UPS and located within the UPS module. The maintenance bypass switch shall provide the capability to continuously support the critical load from the bypass ac power source while the UPS is isolated for maintenance. The maintenance bypass switch shall be housed in an isolated compartment inside the UPS cabinet in such a way that service personnel will not be exposed to electrically live parts while maintaining the unit. Switch shall contain a maintenance bypass protective device and a module isolation protective device.

2.6.2 Load Transfer

The maintenance bypass switch shall provide the capability of transferring the critical load from the UPS static bypass transfer switch to maintenance bypass and then back to the UPS static bypass transfer switch with no interruption to the critical load.

2.6.3 Load Bank Protective Device

A load bank protective device shall be provided to allow the UPS system to be tested using a portable load bank. The load bank protective device shall be connected on the line side of the maintenance bypass switch isolation protective device.

2.7 MODULE CONTROL PANEL

The UPS module shall be provided with a control/indicator panel. The panel shall be on the front of the UPS module. Controls, meters, alarms and indicators for operation of the UPS module shall be on this panel.

2.7.1 Module Meters

2.7.1.1 Monitored Functions

The following functions shall be monitored and displayed:

a. Input voltage, phase-to-phase (all three phases).

b. Input current, all three phases.

c. Input frequency.

d. Battery voltage.

e. Battery current (charge/discharge).

f. Output voltage, phase-to-phase and phase-to-neutral (all three phases).

g. Output current, all three phases.

h. Output frequency.

i. Output kilowatts.

j. Elapsed time meter to indicate hours of operation, 6 digits.

k. Bypass voltage, phase-to-phase and phase-to-neutral (all three phases).

l. Output kilovars.

m. Output kilowatt hours, with 15-minute demand attachment.

2.7.1.2 Meter Construction

Meters shall have 1 percent accuracy and shall be digital type (minimum 4 significant digits).

2.7.2 Module Controls

Module shall have the following controls:

a. Lamp test/reset pushbutton.

b. Alarm test/reset pushbutton.

c. Module input protective device trip pushbutton, with guard.

d. Module output protective device trip pushbutton, with guard.

e. Battery protective device trip pushbutton, with guard.

f. Emergency off pushbutton, with guard.

g. dc voltage adjustment potentiometer, with locking guard.

h. Control power off switch.

i. UPS/bypass transfer selector switch.

j. Static bypass transfer switch enable/disable selector switch.

2.7.3 Module Alarm Indicators

Module shall have indicators for the following alarm items. Any one of these conditions shall turn on an audible alarm and the appropriate summary indicator. Each new alarm shall register without affecting any previous alarm.

a. Input ac power source failure.

b. Input protective device open.

c. Output protective device open.

d. Overload.

e. Overload shutdown.

f. dc overvoltage.

g. dc ground fault.

h. Low battery.

i. Battery discharged.

j. Battery protective device open.

k. Blower failure.

l. Input transformer overtemperature.

m. Inverter transformer overtemperature.

n. Equipment overtemperature.

o. Operating on internal oscillator.

p. Fuse blown.

q. Control power failure.

r. Charger off.

s. Inverter off.

t. Emergency off.

u. UPS on battery.

v. Critical load on static bypass.

w. Static bypass transfer switch disabled.

x. Inverter output overvoltage.

y. Inverter output undervoltage.

z. Inverter output overfrequency.

aa. Inverter output underfrequency.

bb. Bypass source overvoltage.

cc. Bypass source undervoltage.

dd. Bypass source overfrequency.

ee. Bypass source underfrequency.

ff. Bypass source to inverter out of synchronization.

2.7.4 Module Mimic Panel

UPS module shall have a mimic panel in the format of a module single-line diagram, with status indicators for input, output, battery protective devices, and battery disconnect switch. Each protective device shall have indicators for open (green) and closed (red), to give positive indication. The mimic panel shall provide indication of the following additional functions:

a. Charger on (functional).

b. UPS on-line (inverter furnishing load power).

c. UPS on-bypass (static switch operating).

d. System alarm (flashes for abnormalities, minor or major faults).

2.7.5 Module Emergency Off Button

Pressing the emergency off button shall cause the affected module to be disconnected from the system, via its input protective device, output protective device, and battery protective device. Activation of this button shall not affect the operation of the remainder of the system.

2.8 SYSTEM CONTROL CABINET

2.8.1 General Description

The multi-module UPS system shall be provided with a separate control cabinet for system output, summary monitoring, and control. This unit shall contain; bus bar connections to collect the output from each module, the static switch and its bypass breaker, the UPS system output protective device, and the UPS output switchgear.

2.8.2 UPS Output Switchboard

The UPS output switchboard shall consist of a main protective device feeding the UPS output switchboard critical load bus, a load bank protective device (connected on the line side of the main protective device), a maintenance bypass protective device and associated feeder protective devices for the critical loads. A power distribution unit with individual output circuit breakers shall be integral to UPS.

2.8.2.1 Interlocking

The main protective device and the load bank protective device shall be interlocked to prevent both being closed at the same time. The maintenance bypass protective device shall be interlocked with the UPS system output protective device and the static bypass switch. The maintenance bypass protective device shall not be capable of closing until the static bypass switch is closed and the UPS system output protective device is open. Once the maintenance bypass protective device is closed, the UPS output switchgear main protective device shall be capable of opening to isolate the critical loads from the UPS output. The load bank protective device as well as the UPS system output protective device shall then be capable of closing to permit load bank testing.

2.8.2.2 Switchboard

UPS output switchboard shall be provided in accordance with Section 16475 COORDINATED POWER SYSTEM PROTECTION.

2.8.3 System Control Panel

A separate control panel shall be provided for the overall UPS system. The panel shall be on the front surface of the system cabinet. The controls, meters, alarms and indicators for operation of the UPS system shall be on this panel.

2.8.3.1 System Meters

Meters shall have 1 percent accuracy and shall be digital type (minimum 4 significant digits). ac voltages shall be measured as true RMS voltages.

The following functions shall be monitored:

a. Output voltage, phase-to-phase and phase-to-ground (all three phases).

b. Output current, all three phases.

c. Output frequency.

d. Bypass voltage, phase-to-phase and phase-to-ground (all three phases).

e. Output kilowatts.

f. Output kilovars.

g. Output kVA.

h. Output kilowatt-hours, with demand attachment.

i. Maintenance bypass voltage, phase-to-phase and phase-to-ground (all three phases).

2.8.3.2 System Controls

The system cabinet shall include the following controls:

a. Lamp test/reset.

b. Alarm test/reset.

c. Voltage adjustment potentiometer.

d. Emergency off pushbutton with protective cover.

e. UPS/bypass transfer selector switch.

f. Static switch enable/disable selector switch.

g. Control power off switch.

2.8.3.3 System Alarm Indicators

The system control panel shall contain indicators for the following additional alarm items. Any one of these alarm conditions shall also activate the audible alarm. Each new alarm shall register without affecting previous alarms.

a. Module summary alarm, one for each UPS module.

b. UPS on battery.

c. Low battery voltage.

d. Critical load on bypass.

e. Static switch disable.

f. Output overvoltage.

g. Output undervoltage.

h. Output overfrequency.

i. Output underfrequency.

j. Overload.

k. Bypass source overvoltage.

l. Bypass source undervoltage.

m. Bypass source overfrequency.

n. Bypass source underfrequency.

o. Bypass source to inverter out of synchronization.

p. Equipment overtemperature.

q. Control power failure.

2.8.3.4 System Mimic Panel

The system control panel shall contain a mimic panel in the format of a single-line diagram, with status indicators for the following items:

a. Module on-line, one per UPS module.

b. UPS output protective device status, one for closed (red), one for open (green), and one for withdrawn (amber).

c. Static bypass protective device status, one for closed (red), one for open (green), and one for withdrawn (amber).

d. Static switch status, one for connected (red), and one for disconnected (green).

2.8.3.5 Emergency Off

Pressing the emergency off button shall cause the module input, output, and battery circuit breakers to open, completely isolating the UPS system from sources of power. The critical load shall be transferred to the bypass source when this occurs.

2.9 SELF-DIAGNOSTIC CIRCUITS

The control logic shall include status indicators for trouble-shooting the control circuits. These indicators shall be mounted on the circuit card edge or face such that they will be visible without repositioning the card, and shall be labeled with the function name.

2.10 REMOTE MONITORING PANEL

A remote monitoring panel shall be provided to monitor system status. The panel shall be designed for wall mounting near the critical load. Locate as directed by Contracting Officer.

2.10.1 Indicators

Minimum display shall include the following indicators:

a. Load on UPS.

b. Load on battery.

c. Load on bypass.

d. Low battery.

e. Summary alarm.

f. New alarm (to alert the operator that a second summary alarm condition has occurred).

2.10.2 Audible Alarm

Any single indicator shall also turn on the audible alarm. An audible alarm test/reset button and lamp test/reset button shall be included. This reset button shall not affect nor reset the alarm on the module or on the system cabinet.

2.11 TEMPERATURE CONTROL

2.11.1 General

Cabinet and enclosure ventilation shall be adequate to ensure that components are operated within their ratings. Forced-air cooled rectifier, inverter, and control unit will be acceptable. The cooling fans shall continue operation if UPS input power is lost. Redundancy shall be provided so that failure of one fan or associated circuit breaker will not cause an overheat condition. Cooling air shall enter the lower front of the cabinets and exhaust at the top. Blower power failure shall be indicated as a visual and audible alarm on the control panel. Air inlets shall have filters that can be replaced without opening the cabinet doors.

2.11.2 Blower Power Source

Blower power source shall be internally derived from the input and output sides of UPS module, with automatic transfer arrangement.

2.11.3 Temperature Sensors

Temperature sensors shall be provided to monitor the air temperature. Separate sensors shall monitor the temperature of rectifier and inverter heat sinks. Separate sensors shall also monitor the transformer temperature. Critical equipment overtemperature indication shall start a timer that shall shut down the UPS system if the temperature does not return below the setpoint level in 5 minutes.

2.12 BATTERY SYSTEM

2.12.1 General

A storage battery with sufficient ampere-hour rating to maintain UPS output at full capacity for the specified duration shall be provided for each UPS module. The battery shall be of heavy-duty, industrial design suitable for UPS service. The cells shall be provided with flame arrestor vents, intercell connectors and cables, cell-lifting straps, cell-numbering sets, and terminal grease. Intercell connectors shall be sized to maintain terminal voltage within voltage window limits when supplying full load under power failure conditions. Cell and connector hardware shall be stainless steel of a type capable of resisting corrosion from the electrolyte used.

2.12.2 Battery Ratings

a. Type: nickel cadmium.

b. Specific gravity when fully charged: 1.215.

c. End voltage 1.67 volts per cell.

d. Float voltage: 2.17 to 2.26 volts per cell.

e. Equalizing voltage: 2.33 to 2.38 volts per cell.

2.12.3 Battery Construction

*9

The battery shall be of the ~~wet-cell~~standard type and shall be supplied complete with thermometer and hydrometer holder.

2.12.4 Battery Cabinet

The battery pack assembly shall be furnished in a battery cabinet matching the UPS cabinet. The battery cabinet shall be designed to allow for checking the torque on the connections in the battery system and to provide adequate access for annual housekeeping chores. External wiring interface shall be through the bottom or top of the assembly. A smoke and high temperature alarm shall annunciate detection of either smoke or high temperature within the battery cabinet.

2.12.5 Battery Rack

The battery shall be provided with a suitable number of (two-tier) racks to fit the room layout shown. Battery rack shall be steel and shall be protected with electrolyte-resistant paint. Battery rack shall be shipped unassembled and shall include hardware necessary for assembly. Each rack shall be complete with bus bars to accommodate cables from UPS module. Bus bar connectors for battery-to-battery connections and high-flex multi-stranded copper cable (ASTM B 173 stranding class H) with proper cable supports for connecting top row of batteries to bottom row of batteries at rack ends shall be provided. End sections shall be cut to length to prevent wasting floor space.

*9

2.12.6 Deleted~~Cell-Terminal Covers~~

~~Acid-resistant transparent cell-terminal covers not exceeding 6 feet in length and with vent holes drilled on top where needed shall be provided.~~

2.12.7 Battery Disconnect

Each battery pack assembly shall have a fused disconnect switch provided in a NEMA 1 enclosure, finished with acid-resistant paint and located in line with the assembly. Switch shall be complete with line side and load side bus bars for connection to battery cells. Switch shall be rated 600V dc, 200 amperes, 3-pole with interrupting rating as required by system capacity, and shall have an external operator that is lockable in the "off" position.

2.12.8 Seismic Requirements

The battery support system shall conform to Section 16070 "SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT".

2.12.9 Battery Monitor

A battery monitor shall be provided for each battery pack assembly. At a minimum, this device shall monitor the following parameters:

a. Total system voltage.

b. Ambient room temperature.

c. Total battery discharge cycles with a duration of greater than 30 seconds but less than 5 minutes.

The monitor shall also record the total accumulated discharge minutes and accumulated battery system discharge kW hours.

2.13 FACTORY TESTING

The UPS system shall be factory tested to meet the requirements specified using a test battery (not the battery to be supplied with the system). UPS module shall be factory load tested as an independent assembly with 3-phase ac input power and with battery power for a minimum of 8 hours, with meter readings taken every 30 minutes. Load shall be balanced at rated kVA and rated power factor. Factory tests for the UPS module shall be run under full load, and will be witnessed by the Government. Should a malfunction occur, the problem shall be corrected and the test shall be repeated. As a minimum, the factory tests shall include the parameters described in paragraphs ac Input, ac Output, Transient Response and Efficiency. The tests shall encompass all aspects of operation, such as module failure, static bypass operation, battery failure, input power failure and overload ratings. The Government shall be notified in writing at least 2 weeks before testing. Factory-test time shall not be used for system debugging and/or checkout. Such work shall be done prior to notifying the Government that the system is ready for testing. Factory tests shall be performed during normal business hours. The system shall be interconnected and tested for an additional 8 hours to ensure proper wiring and performance.

2.13.1 Transient Tests

Transient tests shall be conducted using high-speed oscillograph type recorders to demonstrate the operation of the components to the satisfaction of the Government. These tests shall include 50 percent to 100 percent load changes, manual transfer, manual retransfer, low dc bus initiated transfer and low ac output bus transfer. A recording instrument equipped with an event marker shall be used.

2.13.2 Efficiency Tests

Testing for efficiency shall be performed at zero output up to 100 percent of stated kVA output in 25 percent steps, 0.9 power factor, with battery fully charged and floating on the dc bus, with nominal input voltage, and with modules connected to the system to represent actual operating conditions.

2.14 INSPECTION

Inspection before shipment is required. The manufacturer shall notify the Government at least 2 weeks before shipping date so that an inspection can be made.

PART 3 EXECUTION

3.1 INSTALLATION

The UPS system shall be set in place, wired and connected in accordance with the approved shop drawings and manufacturer's instructions. The UPS battery shall be shipped to the site dry.

3.2 FIELD SUPERVISION, STARTUP AND TESTING

The services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment specified shall be provided. The representative shall supervise the installation, adjustment and testing of the equipment. The representative shall check the wiring between equipment, start up the system, and field test the functions, interlocks and protective devices to ensure that the total system is functioning according to the intent of the design. The field tests shall be performed under the supervision of a factory-trained representative of the equipment manufacturer and witnessed by the Government. The Government shall be given 2 weeks written advance notice of the date and time when testing will be conducted.

3.2.1 Field Tests

As a minimum, the startup and field test procedures shall include the following:

a. Ensure that shipping members have been removed.

b. Check for damage (dents, scratches, frame misalignment, damage to panel devices, etc).

c. Ensure that interiors are free of foreign materials, tools and dirt.

d. Attach a phase rotation meter to the UPS input, output and bypass buses, and observe proper phase sequences.

e. Torque test bus connections at shipping splits. Also torque test battery connections.

f. Check each electrical bus for proper phasing and identification.

g. Check and test selector switches and meters for proper operation.

h. Check doors for proper alignment and operation.

i. Check and test each protective device for proper mechanical and electrical operation.

j. Check protective device overcurrent trip settings.

k. Check and test indicating lights for proper operation and color.

l. Perform onsite field test procedures.

m. Demonstrate to the Government that the specified functions and interlocks have been implemented.

n. Provide IEEE Std 450 battery installation certification.

o. Check key interlock key numbers, if used, to ensure agreement with interlocking scheme.

3.2.2 Load Test

The installed system shall be load tested for a continuous 24 hour period by means of resistive load banks. The system shall be continuously tested at 1/2 load for 8 hours, 3/4 load for 8 hours and full load for 8 hours. Load banks will be available onsite and shall be connected to UPS equipment by the Contractor. Instrument readings shall be recorded every half hour for the following:

a. Input voltage (all three phases, for each module).

b. Input current (all three phases, for each module).

c. Input frequency.

d. Battery voltage for each module.

e. Output voltage (all three phases, for each module).

f. Output current (all three phases, for each module).

g. Output kilowatts for each module.

h. Output frequency.

i. Output voltage (all three phases - system output).

j. Output current (all three phases - system output).

k. Output kilowatts (system output).

3.2.3 Full Load Burn In Test

The installed system shall undergo an additional full load burn-in period of 24 continuous hours. If a failure occurs during the burn-in period, the tests shall be repeated. Instrument readings shall be recorded every half hour as above. During the burn-in period, the following tests shall be performed:

a. With the UPS carrying maximum continuous design load and supplied from the normal source, switch 100 percent load on and off a minimum of five times within the burn-in period.

b. With the UPS carrying maximum continuous design load and supplied from the emergency source, repeat the switching operations described in step a. Also, verify that the UPS module rectifier charger unit(s) go into the second-step current limit mode.

c. With the UPS carrying maximum continuous design load and operating on battery power, repeat the switching operations described in step a above.

d. Continue operation on battery power for 1 minute, then restore normal power.

The Contractor shall furnish a high-speed dual trace oscillograph to monitor ten or more cycles of the above tests at the ON and OFF transitions and two typical steady-state periods, one shortly after the load is energized (at 30 to 60 seconds) and one after operation has stabilized (at 8 to 10 minutes). Four copies of the traces shall be delivered to the Contracting Officer.

3.2.4 Battery Discharge Test

With the battery fully charged, the system shall undergo a complete battery discharge test to full depletion and a recharge to nominal conditions. Instrument readings shall be recorded every minute during discharge for the following:

a. Battery voltage for each module.

b. Battery current for each module.

c. Output voltage (all three phases) for each module.

d. Output current (all three phases) for each module.

e. Output kilowatts for each module.

f. Output voltage (all three phases - system output).

g. Output current (all three phases - system output).

h. Output kilowatts (system output).

i. Output frequency.

3.3 POSTING FRAMED DATA AND INSTRUCTIONS

Framed data and instructions containing wiring and control diagrams under glass or in laminated plastic shall be posted where directed. Condensed operating instructions, prepared in typed form, shall be framed as specified above and posted beside the diagrams. The framed instructions shall be posted before acceptance testing of the system.

3.4 FIELD TRAINING

A field training course shall be provided for designated operating and maintenance staff members. Training shall be provided for a total period of 12 hours of normal working time and shall start after the system is functionally complete but prior to final acceptance test. Field training shall cover the items contained in the operating and maintenance manuals. The 12 hours shall be divided into two sessions of 6 hours each. Each session shall be conducted on a different day. Field training shall be videotaped and the tape shall be left with the Contracting Officer. A factory training videotape shall be provided as part of the training materials.

UPS SYSTEM PERFORMANCE DATA SHEET   SHEET 1 OF 6

	ITEM	SPECIFIED	SUBMITTED
	SYSTEM OPERATION	[SINGLE MODULE] [PARALLEL REDUNDANT] [PARALLEL NON REDUNDANT]	
	NUMBER OF SYSTEMS	[_____]	
GENERAL	NUMBER OF MODULES IN EACH SYSTEM	PRESENT [_____] FUTURE [_____]	
	SYSTEM CAPACITY: PRESENT FUTURE	 [_____] kW/[_____] kVA [_____] kW/[_____] kVA	
	BATTERY	ONE PER MODULE	
	MTBF (SYSTEM)		
	MTTR		
MODULE	MODULE RATING	[_____] kW/[_____] kVA	
	DC VOLTAGE WINDOW	[_____] Vdc	
	INPUT/OUTPUT PROTECTIVE DEVICE INTERRUPT. RATING	[_____] A SYM.	
BATTERY	MANUFACTURER	___________	
	TYPE	[LEAD-CALCIUM] [LEAD-ANTIMONY] [NICKEL-CADMIUM]	
	DISCHARGE TIME TO END VOLTAGE AT FULL LOAD	[_____] MINUTES	
	END VOLTAGE	[_____] V/CELL	
	SPECIFIC GRAVITY	[_____]	
	FLOAT VOLTAGE	[_____] V/CELL	
	NUMBER OF CELLS	[_____] CELLS	

UPS SYSTEM PERFORMANCE DATA SHEET   SHEET 2 OF 6

	ITEM	SPECIFIED	SUBMITTED
BATT	HYDROGEN GENERATION	___________	
	RECHARGE TIME TO 95% CAPACITY	10 X DISCHARGE	
SYSTEM CABINET	PROTECTIVE DEVICE	[AIR POWER, DRAW-OUT] [_____]	
	MANUFACTURER	____________	
	INTERRUPTING RATE	[_____] A SYM.	
	STATIC SWITCH	[_____] A	
AC INPUT	VOLTS, LINE/LINE	[_____] V	
	PHASES	[3-PHASE, 3-WIRE] [_____]	
	VOLTAGE RANGE	+ 10%, - 15%	
	FREQUENCY	[50] [60] Hz	
	FREQUENCY RANGE	+/- 5%	
	POWER WALK-IN 20% TO 100% LOAD	15 - 24 SECONDS	
	TOTAL HARMONIC DISTORTION REFLECTED-PRIMARY	[5% MAX (CURRENT)] [_____]	
	ORDER OF HARMONIC 2nd 3rd 4th 5th 6th 7th 8th 9th	______	PERCENTAGE OF TOTAL
(FILL IN AS REQUIRED)			
	TRANSFORMER SUB-CYCLE INRUSH	[_____] x FULL LOAD	
	POWER FACTOR	[0.8] [0.9]	

UPS SYSTEM PERFORMANCE DATA SHEET   SHEET 3 OF 6

	ITEM	SPECIFIED	SUBMITTED
	VOLTAGE, LINE-LINE	[_____] V	
	PHASES	3-PHASE, 4-WIRE	
	POWER FACTOR	0.8 LAGGING, 1.0	
	VOLTAGE REGULATION BALANCED LOAD	+/- 1.0%	
	50% IMBALANCE BETWEEN PHASES	+/- 2.0%	
	NO-LOAD MODULATION	+/- 1.0%	
	DRIFT (30 DAYS)	+/- 1.0%	
	VOLTAGE ADJUST.	+/- 5.0% MANUALLY	
AC OUTPUT	FREQUENCY	60 Hz	
	REGULATION	+/- 0.1%	
	DRIFT (24 HRS.)	+/- 0.1%	
	HARMONIC CONTENT TOTAL (50% NON-LINEAR LOAD TOTAL (LINEAR LOAD) SINGLE HARMONIC (LINEAR LOAD)	 7.0% MAX. 5.0% MAX. 3.0% MAX.	
	PHASE DISPLACEMENT BALANCED LOAD	+/- 1.0 DEG. OF BYPASS	
	50% IMBALANCE	+/- 3.0 DEG. OF BYPASS	
	WAVE FORM DEVIATION FACTOR (NO LOAD)	5.0%	
	OVERLOAD CAPACITY 125%	10 MINUTES	
	150%	30 SECONDS	
	300%	MOMENTARY	

UPS SYSTEM PERFORMANCE DATA SHEET   SHEET 4 OF 6

	ITEM	SPECIFIED	SUBMITTED
	LOAD SHARING AMONG MODULES	+/- 5.0% OF AVERAGE LOAD	
	VOLT. TRANSIENT RESPONSE		
	50% STEP LOAD 0% to 50%	+/- 8.0%	
	50% STEP LOAD 50% to 100%	+/- 8.0%	
	LOSS OR RETURN OF INPUT	+/- 1.0%	
	LOSS OR RETURN OF A REDUNDANT MODULE AUTOMATICALLY	+/- 8.0%	
	MANUALLY	+/- 8.0%	
AC OUTPUT	AUTO TRANSFER, AT FULL LOAD, FROM UPS TO BYPASS	+/- 4.0%	
	MANUAL TRANS- FER, AT FULL LOAD, FROM BYPASS TO UPS	+/- 4.0%	
	RECOVERY TIME TO 99% STEADY- STATE COND.	50 MILLISECONDS	
	FREQUENCY TRANS- IENT RESPONSE	+/- 0.5 Hz	
	SLEW RATE	1.0 Hz/SECOND	

UPS SYSTEM PERFORMANCE DATA SHEET SHEET 5 OF 6

	ITEM	SPECIFIED	SUBMITTED
AC OUTPUT	EFFICIENCY @ FULL LOAD MODULE	[_____]%	
	SYSTEM	[_____]%	
ENVIRONMENTAL	SYSTEM NOISE GEN. LEVEL @ 1.8 M FROM EQUIPMENT	[_____] DBA	
	OPERATING AMBIENT TEMPERATURE	0 DEG. C to [40] [50] DEG. C	
	STORAGE AMBIENT TEMPERATURE	-20 DEG. C to +60 DEG. C	
	BATTERY ROOM AMBIENT TEMP.	25 DEG. C NOMINAL	
	RELATIVE HUMIDITY (NON-CONDENSING)	0 - 95%	
	BAROMETRIC PRESSURE (ALTITUDE) OPERATING		
	NON-OPERATING	12,200 M	
	HEAT REJECTION MODULE SYSTEM	_______	
PHYSICAL DATA	MODULE SIZE WEIGHT	_______	
	SYSTEM CABINET SIZE WEIGHT	_______	

UPS SYSTEM PERFORMANCE DATA SHEET   SHEET 6 OF 6

	ITEM		SPECIFIED	SUBMITTED
PHYSICAL DATA	BATTERY		_______	
	SEISMIC PARAMETERS			
	RACKS	SIZE		
		WEIGHT		
	CELLS	SIZE		
		WEIGHT		
	DISCON-NECT	SIZE		
		WEIGHT		

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 16 - ELECTRICAL

SECTION 16375A

ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND

05/01

-- End of Section Table of Contents --

SECTION 16375A

ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND
05/01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C29.1	(1988; R 1996) Electrical Power Insulators - Test Methods
ANSI C57.12.21	(1995) Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Single-Phase Distribution Transformers with High-Voltage Bushings; (High-Voltage, 34 500 Grd Y/19 920 Volts and Below; Low-Voltage, 240/120; 167 kVA and Smaller)
ANSI C57.12.26	(1993) Pad-Mounted Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers for Use with Separable Insulated High-Voltage Connectors, High-Voltage, 34 500 Grd Y/19 920 Volts and Below; 2500 kVa and Smaller
ANSI C80.1	(1995) Rigid Steel Conduit - Zinc Coated
ANSI O5.1	(1992) Specifications and Dimensions for Wood Poles

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 48M	(1994ael) Gray Iron Castings (Metric)
ASTM A 123/A 123M	(2000) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 153/A 153M	(2000) Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM B 3	(1995) Soft or Annealed Copper Wire
ASTM B 8	(1999) Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM B 117	(1997) Operating Salt Spray (Fog) Apparatus

ASTM B 496	(1999) Compact Round Concentric-Lay-Stranded Copper Conductors
ASTM C 478	(1997) Precast Reinforced Concrete Manhole Sections
ASTM C 478M	(1997) Precast Reinforced Concrete Mahhole Sections (Metric)
ASTM D 923	(1997) Sampling Electrical Insulating Liquids
ASTM D 1654	(1992) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D 4059	(1996) Analysis of Polychlorinated Biphenyls in Insulating Liquids by Gas Chromatography

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS6	(1996) Ethylene Propylene Rubber Insulated Shielded Power Cables Rated 5 Through 69 kV

FACTORY MUTUAL ENGINEERING AND RESEARCH (FM)

FM P7825a	(1998) Approval Guide Fire Protection

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(1997) National Electrical Safety Code
IEEE C37.20.1	(1993) Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear
IEEE C37.20.2	(1993; C37.20.2b) Metal-Clad and Station-Type Cubicle Switchgear
IEEE C37.20.3	(1997) Metal-Enclosed Interrupter Switchgear
IEEE C37.34	(1994) Test Code for High-Voltage Air Switches
IEEE C37.41	(1994; C37.41c) Design Tests for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories
IEEE C37.90.1	(1989; R 1994) IEEE Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems
IEEE C37.98	(1987; R 1991) Seismic Testing of Relays
IEEE C57.12.00	(1993) IEEE Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers

IEEE C57.13	(1993) Instrument Transformers
IEEE C57.98	(1993) Guide for Transformer Impulse Tests
IEEE Std 48	(1998) Standard Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5 kV through 765 kV
IEEE Std 81	(1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1)
IEEE Std 100	(1997) IEEE Standard Dictionary of Electrical and Electronics Terms
IEEE Std 242	(1986; R 1991) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
IEEE Std 399	(1997) Recommended Practice for Industrial and Commercial Power Systems Analysis

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA FB 1	(1993) Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies
NEMA TC 6	(1990) PVC and ABS Plastic Utilities Duct for Underground Installation
NEMA WC 8	(1988; Rev 3; 1996) Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1999) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 6	(1997) Rigid Metal Conduit
UL 467	(1993; Rev thru Apr 1999) Grounding and Bonding Equipment
UL 510	(1994; Rev thru Apr 1998) Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(1996; Rev Dec 1999) Metallic Outlet Boxes
UL 651	(1995; Rev thru Oct 1998) Schedule 40 and 80 Rigid PVC Conduit
UL 1072	(1995; Rev Mar 1998) Medium Voltage Power

	Cable
UL 1242	(1996; Rev Mar 1998) Intermediate Metal Conduit

1.2 GENERAL REQUIREMENTS

1.2.1 Terminology

Terminology used in this specification is as defined in IEEE Std 100.

1.2.2 Service Conditions

Items provided under this section shall be specifically suitable for the following service conditions. Seismic details shall conform to Sections 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 16070 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

*8

SD-02 Shop Drawings

Electrical Distribution System; G, RE~~AE~~

Detail drawings consisting of equipment drawings, illustrations, schedules, instructions, diagrams manufacturers standard installation drawings and other information necessary to define the installation and enable the Government to check conformity with the requirements of the contract drawings.

If departures from the contract drawings are deemed necessary by the Contractor, complete details of such departures shall be included with the detail drawings. Approved departures shall be made at no additional cost to the Government.

Detail drawings shall show how components are assembled, function together and how they will be installed on the project. Data and drawings for component parts of an item or system shall be coordinated and submitted as a unit. Data and drawings shall be coordinated and included in a single submission. Multiple submissions for the same equipment or system are not acceptable except where prior approval has been obtained from the Contracting Officer. In such cases, a list of data to be submitted later shall be included with the first submission. Detail drawings shall consist of the following:

a. Detail drawings showing physical arrangement, construction details, connections, finishes, materials used in fabrication, provisions for conduit or busway entrance, access requirements for installation and maintenance, physical size, electrical characteristics, foundation and support details, and equipment weight. Drawings shall be drawn to scale and/or dimensioned. All optional items shall be clearly identified as included or excluded.

b. Internal wiring diagrams of equipment showing wiring as actually provided for this project. External wiring connections shall be clearly identified.

Detail drawings shall as a minimum depict the installation of the following items:

1. Transformers.

2. Switchgear.

3. Busways.

4. Surge arresters.

As-Built Drawings; G, RE

The as-built drawings shall be a record of the construction as installed. The drawings shall include the information shown on the contract drawings as well as deviations, modifications, and changes from the contract drawings, however minor. The as-built drawings shall be a full sized set of prints marked to reflect deviations, modifications, and changes. The as-built drawings shall be complete and show the location, size, dimensions, part identification, and other information. Additional sheets may be added. The as-built drawings shall be jointly inspected for accuracy and completeness by the Contractor's quality control representative and by the Contracting Officer prior to the submission of each monthly pay estimate. Upon completion of the work, the Contractor shall provide three full sized sets of the marked prints to the Contracting Officer for approval. If upon review, the as-built drawings are found to contain errors and/or omissions, they will be returned to the Contractor for correction. The Contractor shall correct and return the as-built drawings to the Contracting Officer for approval within 10 calendar days from the time the drawings are returned to the Contractor.

SD-03 Product Data

Fault Current Analysis; G, AE
Protective Device; G, AE
Coordination Study; G, AE

The study shall be submitted with protective device equipment submittals. No time extension or similar contract modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed shall be based on recommendations of this study. The Government shall not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study.

Nameplates~~; G, AE~~

Catalog cuts, brochures, circulars, specifications, product data, and printed information in sufficient detail and scope to verify compliance with the requirements of the contract documents.

Material and Equipment~~; G, AE~~

A complete itemized listing of equipment and materials proposed for incorporation into the work. Each entry shall include an item number, the quantity of items proposed, and the name of the manufacturer of each such item.

General Installation Requirements~~; G, AE~~

As a minimum, installation procedures for transformers, substations, switchgear, and splices.

Procedures shall include cable pulling plans, diagrams, instructions, and precautions required to install, adjust, calibrate, and test the devices and equipment.

SD-06 Test Reports

Factory Tests; G, RE

Certified factory test reports shall be submitted when the manufacturer performs routine factory tests, including tests required by standards listed in paragraph REFERENCES. Results of factory tests performed shall be certified by the manufacturer, or an approved testing laboratory, and submitted within 7 days following successful completion of the tests. The manufacturer's pass-fail criteria for tests specified in paragraph FIELD TESTING shall be included.

Field Testing; G, RE

A proposed field test plan, 30 days prior to testing the installed system. No field test shall be performed until the test plan is approved. The test plan shall consist of complete field test procedures including tests to be performed, test equipment required, and tolerance limits.

Operating Tests; G, RE

Six copies of the information described below in 215.9 by 279.4 mm binders having a minimum of three rings, including a separate section for each test. Sections shall be separated by heavy plastic dividers with tabs.

a. A list of equipment used, with calibration certifications.

b. A copy of measurements taken.

c. The dates of testing.

d. The equipment and values to be verified.

e. The condition specified for the test.

f. The test results, signed and dated.

g. A description of adjustments made.

Cable Installation; G, RE~~AE~~

Six copies of the information described below in 215.9 by 279.4 mm binders having a minimum of three rings from which material may readily be removed and replaced, including a separate section for each cable pull. Sections shall be separated by heavy plastic dividers with tabs, with all data sheets signed and dated by the person supervising the pull.

a. Site layout drawing with cable pulls numerically identified.

b. A list of equipment used, with calibration certifications. The manufacturer and quantity of lubricant used on pull.

c. The cable manufacturer and type of cable.

d. The dates of cable pulls, time of day, and ambient temperature.

e. The length of cable pull and calculated cable pulling tensions.

f. The actual cable pulling tensions encountered during pull.

SD-07 Certificates

Material and Equipment; G, RE~~AE~~

Where materials or equipment are specified to conform to the standards of the Underwriters Laboratories (UL) or to be constructed or tested, or both, in accordance with the standards of the American National Standards Institute (ANSI), the Institute of Electrical and Electronics Engineers (IEEE), or the National Electrical Manufacturers Association (NEMA), the Contractor shall submit proof that the items provided conform to such requirements. The label of, or listing by, UL will be acceptable as evidence that the items conform. Either a certification or a published catalog specification data statement, to the effect that the item is in accordance with the referenced ANSI or IEEE standard, will be acceptable as evidence that the item conforms. A similar certification or published catalog specification data statement to the effect that the item is in accordance with the referenced NEMA standard, by a company listed as a member company of NEMA, will be acceptable as evidence that the item conforms. In lieu of such certification or published data, the Contractor may submit a certificate from a recognized testing agency equipped and competent to perform such services, stating that the items have been tested and that they conform to the requirements listed, including methods of testing of the specified agencies. Compliance with above-named requirements does not relieve the Contractor from compliance with any other requirements of the specifications.

Cable Installer Qualifications; G, RE

The Contractor shall provide at least one onsite person in a supervisory position with a documentable level of competency and experience to supervise all cable pulling operations. A resume shall be provided showing the cable installers' experience in the last three years, including a list of references complete with points of contact, addresses and telephone numbers.

SD-10 Operation and Maintenance Data

Electrical Distribution System; G, RE

Six copies of operation and maintenance manuals, within 7 calendar days following the completion of tests and including assembly, installation, operation and maintenance instructions, spare parts data which provides supplier name, current cost, catalog order number, and a recommended list of spare parts to be stocked. Manuals shall also include data outlining detailed procedures for system startup and operation, and a troubleshooting guide which lists possible operational problems and corrective action to be taken. A brief description of all equipment, basic operating features, and routine maintenance requirements shall also be included. Documents shall be bound in a binder marked or identified on the spine and front cover. A table of contents page shall be included and marked with pertinent contract information and contents of the manual. Tabs shall be provided to separate different types of documents, such as catalog ordering information, drawings, instructions, and spare parts data. Index sheets shall be provided for each section of the manual when warranted by the quantity of documents included under separate tabs or dividers.

Three additional copies of the instructions manual shall be provided within 30 calendar days following the manuals.

1.4 DELIVERY, STORAGE, AND HANDLING

Devices and equipment shall be visually inspected by the Contractor when received and prior to acceptance from conveyance. Stored items shall be protected from the environment in accordance with the manufacturer's published instructions. Damaged items shall be replaced. Oil filled transformers and switches shall be stored in accordance with the manufacturer's requirements. Wood poles held in storage for more than 2 weeks shall be stored in accordance with ANSI O5.1. Handling of wood poles shall be in accordance with ANSI O5.1, except that pointed tools capable of producing indentations more than 25 mm in depth shall not be used. Metal poles shall be handled and stored in accordance with the manufacturer's instructions.

1.5 EXTRA MATERIALS

One additional spare fuse or fuse element for each furnished fuse or fuse element shall be delivered to the contracting officer when the electrical system is accepted. Two complete sets of all special tools required for maintenance shall be provided, complete with a suitable tool box. Special tools are those that only the manufacturer provides, for special purposes (to access compartments, or operate, adjust, or maintain special parts).

PART 2 PRODUCTS

2.1 STANDARD PRODUCT

Material and equipment shall be the standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Items of the same classification shall be identical including equipment, assemblies, parts, and components.

2.2 NAMEPLATES

2.2.1 General

Each major component of this specification shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a nameplate securely attached to the equipment. Nameplates shall be made of noncorrosive metal. Equipment containing liquid dielectrics shall have the type of dielectric on the nameplate. Sectionalizer switch nameplates shall have a schematic with all switch positions shown and labeled. As a minimum, nameplates shall be provided for transformers, circuit breakers, meters, switches, and switchgear.

2.2.2 Liquid-Filled Transformer Nameplates

Power transformers shall be provided with nameplate information in accordance with IEEE C57.12.00. Nameplates shall indicate the number of liters and composition of liquid-dielectric, and shall be permanently marked with a statement that the transformer dielectric to be supplied is non-polychlorinated biphenyl. If transformer nameplate is not so marked, the Contractor shall furnish manufacturer's certification for each transformer that the dielectric is non-PCB classified, with less than 50 ppm PCB content in accordance with paragraph LIQUID DIELECTRICS. Certifications shall be related to serial numbers on transformer nameplates. Transformer dielectric exceeding the 50 ppm PCB content or transformers without certification will be considered as PCB insulated and will not be accepted.

2.3 CORROSION PROTECTION

2.3.1 Aluminum Materials

Aluminum shall not be used.

2.3.2 Ferrous Metal Materials

2.3.2.1 Hardware

Ferrous metal hardware shall be hot-dip galvanized in accordance with ASTM A 153/A 153M and ASTM A 123/A 123M.

2.3.2.2 Equipment

Equipment and component items, including but not limited to transformer stations and ferrous metal luminaries not hot-dip galvanized or porcelain enamel finished, shall be provided with corrosion-resistant finishes which shall withstand 120 hours of exposure to the salt spray test specified in ASTM B 117 without loss of paint or release of adhesion of the paint primer coat to the metal surface in excess of 1.6 mm from the test mark. The scribed test mark and test evaluation shall be in accordance with ASTM D 1654 with a rating of not less than 7 in accordance with TABLE 1, (procedure A). Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill galvanized sheet steel shall be coated with a zinc rich paint conforming to the manufacturer's standard.

2.3.3   Finishing

Painting required for surfaces not otherwise specified and finish painting of items only primed at the factory shall be as specified in Section 09900 PAINTING, GENERAL.

2.4   CABLES

Cables shall be single conductor type unless otherwise indicated.

2.4.1   Medium-Voltage Cables

2.4.1.1   General

Cable construction shall be Type MV, conforming to NFPA 70 and UL 1072 Cables shall be manufactured for use in duct applications as indicated.

2.4.1.2   Ratings

Cables shall be rated for a circuit voltage of 15 kV

2.4.1.3   Conductor Material

Underground cables shall be soft drawn copper complying with ASTM B 3 and ASTM B 8 for regular concentric and compressed stranding or ASTM B 496 for compact stranding.

2.4.1.4   Insulation

Cable insulation shall be ethylene-propylene-rubber (EPR) insulation conforming to the requirements of NEMA WC 8 and AEIC CS6. A 133 percent insulation level shall be used on 15 kV rated cables. Recyclable materials (insulation) shall conform to EPA requirements in accordance with Section 01670 RECYCLED / RECOVERED MATERIALS.

2.4.1.5   Shielding

Cables rated for 2 kV and above shall have a semiconducting conductor shield, a semiconducting insulation shield, and an overall copper tape shield for each phase. The shield tape shall be sized to meet IEEE C2 requirements for a ground fault availability of 100,000 amperes.

2.4.1.6   Neutrals

Neutral conductors of shall be copper employing the same insulation and jacket materials as phase conductors, except that a 600-volt insulation rating is acceptable.

2.4.1.7   Jackets

Cables shall be provided with a PVC jacket. Direct buried cables shall be rated for direct burial.

2.4.2   Low-Voltage Cables

Cables shall be rated 600 volts and shall conform to the requirements of NFPA 70, and must be UL listed for the application or meet the applicable section of either ICEA or NEMA standards.

2.4.2 Conductor Material

Underground cables shall be annealed copper complying with ASTM B 3 and ASTM B 8. Intermixing of copper and aluminum conductors is not permitted.

2.4.3 Insulation

Insulation must be in accordance with NFPA 70, and must be UL listed for the application or meet the applicable sections of either ICEA, or NEMA standards.

2.4.4 Jackets

Multiconductor cables shall have an overall PVC outer jacket.

2.4.2.5 In Duct

Cables shall be single-conductor cable, in accordance with NFPA 70.

2.5 CABLE JOINTS, TERMINATIONS, AND CONNECTORS

2.5.1 Terminations

Terminations shall be in accordance with IEEE Std 48, Class 1 or Class 2; of the molded elastomer, wet-process porcelain, prestretched elastomer, heat-shrinkable elastomer, or taped type. Acceptable elastomers are track-resistant silicone rubber or track-resistant ethylene propylene compounds, such as ethylene propylene rubber or ethylene propylene diene monomer. Separable insulated connectors may be used for apparatus terminations, when such apparatus is provided with suitable bushings. Terminations shall be of the outdoor type, except that where installed inside outdoor equipment housings which are sealed against normal infiltration of moisture and outside air, indoor, Class 2 terminations are acceptable. Class 3 terminations are not acceptable. Terminations, where required, shall be provided with mounting brackets suitable for the intended installation and with grounding provisions for the cable shielding, metallic sheath, and armor.

2.5.1.1 Factory Preformed Type

Molded elastomer, wet-process porcelain, prestretched, and heat-shrinkable terminations shall utilize factory preformed components to the maximum extent practicable rather than tape build-up. Terminations shall have basic impulse levels as required for the system voltage level. Leakage distances shall comply with wet withstand voltage test requirements of IEEE Std 48 for the next higher Basic Insulation Level (BIL) level.

2.5.1.2 Taped Terminations

Taped terminations shall use standard termination kits providing terminal connectors, field-fabricated stress cones, and rain hoods. Terminations shall be at least 510mm 1.2m long from the end of the tapered cable jacket to the start of the terminal connector, or not less than the kit manufacturer's recommendations, whichever is greater.

2.6 CONDUIT AND DUCTS

Duct lines shall be concrete-encased, thin-wall type.

2.6.1 Metallic Conduit

Intermediate metal conduit shall comply with UL 1242. Rigid galvanized steel conduit shall comply with UL 6 and ANSI C80.1. Metallic conduit fittings and outlets shall comply with UL 514A and NEMA FB 1.

2.6.2 Nonmetallic Ducts

2.6.2.1 Concrete Encased Ducts

UL 651 Schedule 40 or NEMA TC 6 Type EB.

2.6.2.2 Direct Burial

UL 651 Schedule 80 as indicated, or NEMA TC 6 Type DB.

2.6.3 Conduit Sealing Compound

Compounds for sealing ducts and conduit shall have a putty-like consistency workable with the hands at temperatures as low as 2 degrees C , shall neither slump at a temperature of 150 degrees C , nor harden materially when exposed to the air. Compounds shall adhere to clean surfaces of fiber or plastic ducts; metallic conduits or conduit coatings; concrete, masonry, or lead; any cable sheaths, jackets, covers, or insulation materials; and the common metals. Compounds shall form a seal without dissolving, noticeably changing characteristics, or removing any of the ingredients. Compounds shall have no injurious effect upon the hands of workmen or upon materials.

2.7 MANHOLES, HANDHOLES, AND PULLBOXES

Manholes, handholes, and pullboxes shall be as indicated. Strength of manholes, handholes, and pullboxes and their frames and covers shall conform to the requirements of IEEE C2. Precast-concrete manholes shall have the required strength established by ASTM C 478, ASTM C 478M. Frames and covers shall be made of gray cast iron and a machine-finished seat shall be provided to ensure a matching joint between frame and cover. Cast iron shall comply with ASTM A 48M , Class 30B, minimum. Handholes for low voltage cables installed in parking lots, sidewalks, and turfed areas shall be fabricated from an aggregate consisting of sand and with continuous woven glass strands having an overall compressive strength of at least 69 MPa and a flexural strength of at least 34.5 MPa . Pullbox and handhole covers in sidewalks, and turfed areas shall be of the same material as the box. Concrete pullboxes shall consist of precast reinforced concrete boxes, extensions, bases, and covers.

2.8 TRANSFORMERS

Transformers shall be of the outdoor type having the ratings and arrangements indicated. Medium-voltage ratings of cable terminations shall be 15kV between phases for 133 percent insulation level.

2.8.1 Pad-Mounted Transformers

Pad-mounted transformers shall comply with ANSI C57.12.26 and shall be of the radial type. Pad-mounted transformer stations shall be assembled and coordinated by one manufacturer and each transformer station shall be shipped as a complete unit so that field installation requirements are limited to mounting each unit on a concrete pad and connecting it to primary and secondary lines. Stainless steel pins and hinges shall be provided. Barriers shall be provided between high- and low-voltage compartments. High-voltage compartment doors shall be interlocked with low-voltage compartment doors to prevent access to any high-voltage section unless its associated low-voltage section door has first been opened. Compartments shall be sized to meet the specific dimensional requirements of ANSI C57.12.26. Pentahead locking bolts shall be provided with provisions for a padlock.

2.8.1.1 High-Voltage Compartments

The high-voltage compartment shall be dead-front construction. Primary switching and protective devices shall include loadbreak switching, oil-immersed, bayonet-type, overload fuse in series with a partial range current-limiting fuse, medium-voltage separable loadbreak connectors, universal bushing wells and inserts or integral one piece bushings and surge arresters. Fuses shall comply with the requirements of paragraph METERING AND PROTECTIVE DEVICES. The switch shall be mounted inside transformer tank with switch operating handle located in high-voltage compartment and equipped with metal loop for hook stick operation. Fuses shall be interlocked with switches so that fuses can be removed only when the associated switch is in the "OPEN" position. Adjacent to medium-voltage cable connections, a nameplate or equivalent stencilled inscription shall be provided inscribed "DO NOT OPEN CABLE CONNECTORS UNLESS SWITCH IS OPEN." Surge arresters shall be fully insulated and configured to terminate on the same bushing as the primary cable by means of a loadbreak, feed-through bushing insert.

2.8.1.2 Load-Break Switch

Radial-feed oil-immersed type rated at 15 kV, 95 kV BIL, with a continuous current rating and load-break rating of 200 ampere, and a make-and-latch rating of 10,000 rms amperes symmetrical. Locate the switch handle in the high-voltage compartment.

2.8.1.3 Transformer Tank Sections

Transformers shall comply with IEEE C57.12.00, ANSI C57.12.21, and ANSI C57.12.26 and shall be of the dimethyl silicone liquid. Transformers shall be suitable for outdoor use and shall have 2 separate windings per phase. Standard NEMA primary taps shall be provided. Where primary taps are not specified, 4, 2-1/2 percent rated kVA high-voltage taps shall be provided 2 above and 2 below rated, primary voltage. Operating handles for primary tap changers for de-energized operation shall be located within high-voltage compartments, externally to transformer tanks. Adjacent to the tap changer operating handle, a nameplate or equivalent stenciled inscription shall be provided and inscribed "DO NOT OPERATE UNDER LOAD." Transformer ratings at 60 Hz shall be as follows:

Three-phase capacity.....................................3000/3360kVA.

Impedance..   ....5.75%.

Temperature Rise......................................55/65 degrees C.

High-voltage winding... ....12,470 volts.

High-voltage winding connections.........................12,470 volts.

Low-voltage winding............... ....480/277 volts.

Low-voltage winding connections........ 480

2.8.1.4 Accessories

High-voltage warning signs shall be permanently attached to each side of transformer stations. Voltage warning signs shall comply with IEEE C2. Copper-faced steel or stainless steel ground connection pads shall be provided in both the high- and low-voltage compartments. Dial-type thermometer, liquid-level gauge, and drain valve with built-in sampling device shall be provided for each transformer station. Insulated-bushing-type parking stands shall be provided adjacent to each separable load-break elbow to provide for cable isolation during sectionalizing operations.

2.9 GROUNDING AND BONDING

2.9.1 Driven Ground Rods

Ground rods shall be copper-clad steel conforming to UL 467not less than 19 mm in diameter by 3.1 m in length. Sectional type rods may be used.

2.9.2 Grounding Conductors

Grounding conductors shall be bare, except where installed in conduit with associated phase conductors. Insulated conductors shall be of the same material as phase conductors and green color-coded, except that conductors shall be rated no more than 600 volts. Bare conductors shall be ASTM B 8 soft-drawn unless otherwise indicated. Aluminum is not acceptable.

2.10 CONCRETE AND REINFORCEMENT

Concrete work shall have minimum 20 MPa compressive strength and conform to the requirements of Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE. Concrete reinforcing shall be as specified in Section 03200 CONCRETE REINFORCEMENT.

2.11 PADLOCKS

Padlocks shall comply with Section 08710 DOOR HARDWARE.

2.12 CABLE FIREPROOFING SYSTEMS

Cable fireproofing systems shall be listed in FM P7825a as a fire-protective coating or tape approved for grouped electrical conductors and shall be suitable for application on the type of medium-voltage cables provided. After being fully cured, materials shall be suitable for use where exposed to oil, water, gases, salt water, sewage, and fungus and shall not damage cable jackets or insulation. Asbestos materials are not acceptable.

2.12.1 Fireproof Coating

Cable fireproofing coatings shall be compounded of water-based thermoplastic resins, flame-retardant chemicals, and inorganic noncombustible fibers and shall be suitable for the application methods used. Coatings applied on bundled cables shall have a derating factor of less than 5 percent, and a dielectric strength of 95 volts per mil minimum after curing.

2.12.2 Fireproofing Tape

Fireproofing tape shall be at least 50 mm wide and shall be a flexible, conformable, polymeric, elastomer tape designed specifically for fireproofing cables.

2.12.3 Plastic Tape

Preapplication plastic tape shall be pressure sensitive, 0.254 mm (10 mil) thick, conforming to UL 510.

2.13 LIQUID DIELECTRICS

Liquid dielectrics for transformers, capacitors, reclosers, and other liquid-filled electrical equipment shall be non-polychlorinated biphenyl (PCB) mineral-oil or less-flammable liquid as specified. Nonflammable fluids shall not be used. Tetrachloroethylene (perchloroethylene) and 1, 2, 4 trichlorobenzene fluids shall not be used. Liquid dielectrics in retrofitted equipment shall be certified by the manufacturer as having less than 50 parts per million (ppm) PCB content. In lieu of the manufacturer's certification, the Contractor may submit a test sample of the dielectric in accordance with ASTM D 923 and have tests performed per ASTM D 4059 at a testing facility approved by the Contracting Officer. Equipment with test results indicating PCB level exceeding 50 ppm shall be replaced.

2.14 FACTORY TESTS

Factory tests shall be performed, as follows, in accordance with the applicable publications and with other requirements of these specifications. The Contracting Officer shall be notified at least 10 days before the equipment is ready for testing. The Contracting Officer reserves the right to witness the tests.

a. Transformers: Manufacturer's standard routine tests in accordance with IEEE C57.12.00.

b. Transformers rated 200 kVA and above: Reduced full-wave, chopped-wave, and full-wave impulse test on each line and neutral terminal, in accordance with IEEE C57.98.

c. High-Voltage Air Switches: Manufacturer's standard tests in accordance with IEEE C37.34 and IEEE C37.41.

d. Protective Relays: Seismic tests in accordance with IEEE C37.98. Surge withstand tests in accordance with IEEE C37.90.1.

e. Relaying Current Transformers: Manufacturer's standard tests in accordance with IEEE C57.13.

f. Instrument Current Transformers: Manufacturer's standard tests in accordance with IEEE C57.13.

g. Factory Preformed Terminations: Wet withstand voltage tests in accordance with IEEE Std 48 for the next higher BIL level.

h. Outdoor Switchgear: Manufacturer's standard tests in accordance with IEEE C37.20.1, IEEE C37.20.2, and IEEE C37.20.3.

i. Electrical Power Insulators: Manufacturer's standard tests in accordance with ANSI C29.1.

2.15 COORDINATED POWER SYSTEM PROTECTION

Analyses shall be prepared to demonstrate that the equipment selected and system constructed meet the contract requirements for equipment ratings, coordination, and protection. They shall include a load flow analysis, a fault current analysis, and a protective device coordination study. The studies shall be performed by a registered professional engineer with demonstrated experience in power system coordination in the last three years. The Contractor shall provide a list of references complete with points of contact, addresses and telephone numbers. The selection of the engineer is subject to the approval of the Contracting Officer.

2.15.1 Scope of Analyses

The fault current analysis, and protective device coordination study shall begin at the source bus and extend down to system bused where fault availability is 10,000 amperes (symmetrical) for building/facility 600 volt level distribution buses.

2.15.2 Determination of Facts

The time-current characteristics, features, and nameplate data for each existing protective device shall be determined and documented. The Contractor shall coordinate with the commercial power company for fault current availability at the site.

2.15.3 Single Line Diagram

A single line diagram shall be prepared to show the electrical system buses, devices, transformation points, and all sources of fault current (including generator and motor contributions). A fault-impedance diagram or a computer analysis diagram may be provided. Each bus, device or transformation point shall have a unique identifier. If a fault-impedance diagram is provided, impedance data shall be shown. Locations of switches, breakers, and circuit interrupting devices shall be shown on the diagram together with available fault data, and the device interrupting rating.

2.15.4 Fault Current Analysis

2.15.4.1 Method

The fault current analysis shall be performed in accordance with methods described in IEEE Std 242, and IEEE Std 399.

2.15.4.2 Data

Actual data shall be utilized in fault calculations. Bus characteristics and transformer impedances shall be those proposed. Data shall be documented in the report.

2.15.5 Coordination Study

The study shall demonstrate that the maximum possible degree of selectively has been obtained between devices specified, consistent with protection of equipment and conductors from damage from overloads and fault conditions. The study shall include a description of the coordination of the protective devices in this project. Provide a written narrative that describes: which devices may operate in the event of a fault at each bus; the logic used to arrive at device ratings and settings; situations where system coordination is not achievable due to device limitations (an analysis of any device curves which overlap); coordination between upstream and downstream devices; and any relay settings. Recommendations to improve or enhance system reliability, and detail where such changes would involve additions or modifications to the contract and cost changes (addition or reduction) shall be provided. Composite coordination plots shall be provided on log-log graph paper.

2.15.6 Study Report

a. The report shall include a narrative describing: the analyses performed; the bases and methods used; and the desired method of coordinated protection of the power system.

b. The study shall include descriptive and technical data for existing devices and new protective devices proposed. The data shall include manufacturers published data, nameplate data, and definition of the fixed or adjustable features of the existing or new protective devices.

c. The report shall document utility company data including system voltages, fault MVA, system X/R ratio, time-current characteristics curves, current transformer ratios, and relay device numbers and settings.

d. The report shall contain fully coordinated composite time-current characteristic curves for each bus in the system, as required to ensure coordinated power system protection between protective devices or equipment. The report shall include recommended ratings and settings of all protective devices in tabulated form.

e. The report shall provide the calculation performed for the analyses, including computer analysis programs utilized. The name of the software package, developer, and version number shall be provided.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

Equipment and devices shall be installed and energized in accordance with the manufacturer's published instructions. Steel conduits installed underground shall be installed and protected from corrosion in conformance with the requirements of Section 16415 ELECTRICAL WORK, INTERIOR. Except as covered herein, excavation, trenching, and backfilling shall conform to the requirements of Section 02316 EXCAVATION, TRENCHING, AND BACKFILLING FOR UTILITIES SYSTEMS. Concrete work shall have minimum 20 MPa compressive strength and conform to the requirements of Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE.

3.1.1 Conformance to Codes

The installation shall comply with the requirements and recommendations of NFPA 70 and IEEE C2 as applicable.

3.1.2 Verification of Dimensions

The Contractor shall become familiar with details of the work, shall verify dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing any work.

3.1.3 Disposal of Liquid Dielectrics

PCB-contaminated dielectrics must be marked as PCB and transported to and incinerated by an approved EPA waste disposal facility. The Contractor shall furnish certification of proper disposal. Contaminated dielectrics shall not be diluted to lower the contamination level.

3.2 CABLE AND BUSWAY INSTALLATION

The Contractor shall obtain from the manufacturer an installation manual or set of instructions which addresses such aspects as cable construction, insulation type, cable diameter, bending radius, cable temperature, lubricants, coefficient of friction, conduit cleaning, storage procedures, moisture seals, testing for and purging moisture, etc. The Contractor shall then prepare a checklist of significant requirements which shall be submitted along with the manufacturers instructions in accordance with SUBMITTALS.

3.2.1 Cable Installation Plan and Procedure

Cable shall be installed strictly in accordance with the cable manufacturer's recommendations. Each circuit shall be identified by means of a fiber, laminated plastic, or non-ferrous metal tags, or approved equal, in each manhole, handhole, junction box, and each terminal. Each tag shall contain the following information; cable type, conductor size, circuit number, circuit voltage, cable destination and phase identification.

3.2.1.1 Cable Inspection

The cable reel shall be inspected for correct storage positions, signs of physical damage, and broken end seals. If end seal is broken, moisture shall be removed from cable in accordance with the cable manufacturer's recommendations.

3.2.1.2 Duct Cleaning

Duct shall be cleaned with an assembly that consists of a flexible mandrel (manufacturers standard product in lengths recommended for the specific size and type of duct) that is 6.4 mm less than inside diameter of duct, 2 wire brushes, and a rag. The cleaning assembly shall be pulled through conduit a minimum of 2 times or until less than a volume of 131 cubic centimeters of debris is expelled from the duct.

3.2.1.3 Duct Lubrication

The cable lubricant shall be compatible with the cable jacket for cable that is being installed. Application of lubricant shall be in accordance with lubricant manufacturer's recommendations.

3.2.1.4 Cable Installation

The Contractor shall provide a cable feeding truck and a cable pulling winch as required. The Contractor shall provide a pulling grip or pulling eye in accordance with cable manufacturer's recommendations. The pulling grip or pulling eye apparatus shall be attached to polypropylene or manilla rope followed by lubricant front end packs and then by power cables. A dynamometer shall be used to monitor pulling tension. Pulling tension shall not exceed cable manufacturer's recommendations. The Contractor shall not allow cables to cross over while cables are being fed into duct. For cable installation in cold weather, cables shall be kept at 10 degrees C temperature for at least 24 hours before installation.

3.2.1.5 Cable Installation Plan

The Contractor shall submit a cable installation plan for all cable pulls in accordance with the detail drawings portion of paragraph SUBMITTALS. Cable installation plan shall include:

a. Site layout drawing with cable pulls identified in numeric order of expected pulling sequence and direction of cable pull.

b. List of cable installation equipment.

c. Lubricant manufacturer's application instructions.

d. Procedure for resealing cable ends to prevent moisture from entering cable.

e. Cable pulling tension calculations of all cable pulls.

f. Cable percentage conduit fill.

g. Cable sidewall thrust pressure.

h. Cable minimum bend radius and minimum diameter of pulling wheels used.

i. Cable jam ratio.

j. Maximum allowable pulling tension on each different type and size of conductor.

k. Maximum allowable pulling tension on pulling device.

3.2.2 Duct Line

shall be installed in duct lines where indicated. Neutral and grounding conductors shall be installed in the same duct with their associated phase conductors.

3.2.3 Electric Manholes

Cables shall be routed around the interior walls and securely supported from walls on cables racks. Cable routing shall minimize cable crossover, provide access space for maintenance and installation of additional cables, and maintain cable separation in accordance with IEEE C2.

3.2.4 Busway Installation

Busways penetrating walls shall have wall flanges installed on both surfaces of walls. Wall openings shall be approximately 6.4 mm larger than the busway on each of the 4 busway sides, and openings shall be sealed with a suitable compound. Fire barriers shall be provided when penetrating fire rated walls. Fire barriers shall have a rating equal to the fire wall rating. A weather barrier shall be used when a busway penetrates an exterior wall. Busways shall be supported at intervals not exceeding 3 m and shall be braced to prevent lateral movement.

3.3 CABLE JOINTS

Medium-voltage cable joints shall be made by qualified cable splicers only. Qualifications of cable splicers shall be submitted in accordance with paragraph SUBMITTALS. Shields shall be applied as required to continue the shielding system through each entire cable joint. Shields may be integrally molded parts of preformed joints. Shields shall be grounded at each joint or in accordance with manufacturer's recommended practice. Cable joints shall provide insulation and jacket equivalent to that of the associated cable. Armored cable joints shall be enclosed in compound-filled, cast-iron or alloy, splice boxes equipped with stuffing boxes and armor clamps of a suitable type and size for the cable being installed.

3.4 FIREPROOFING

Each medium-voltage cable and conductor in manholes shall be fire-proofed for their entire length within the manhole. Where cables and conductors have been lubricated to enhance pulling into ducts, the lubricant shall be removed from cables and conductors exposed in the manhole before fireproofing.

3.4.1 Tape Method

Before application of fireproofing tape, plastic tape wrapping shall be applied over exposed metallic items such as the cable ground wire, metallic outer covering, or armor to minimize the possibility of corrosion from the fireproofing materials and moisture. Before applying fireproofing tape, irregularities of cables, such as at cable joints, shall be evened out with insulation putty. A flexible conformable polymeric elastomer fireproof tape shall be wrapped tightly around each cable spirally in 1/2 lapped wrapping or in 2 butt-jointed wrappings with the second wrapping covering the joints of the first.

3.4.2 Sprayable Method

Manholes shall be power ventilated until coatings are dry and dewatered and the coatings are cured. Ventilation requirements shall be in accordance with the manufacturer's instruction, but not less than 10 air changes per hour shall be provided. Cable coatings shall be applied by spray, brush, or glove to a wet film thickness that reduces to the dry film thickness approved for fireproofing by FM P7825a. Application methods and necessary safety precautions shall be in accordance with the manufacturers instructions. After application, cable coatings shall be dry to the touch in 1 to 2 hours and fully cured in 48 hours, except where the manufacturer has stated that because of unusual humidity or temperature, longer periods may be necessary.

3.5 DUCT LINES

3.5.1 Requirements

Numbers and sizes of ducts shall be as indicated. Duct lines shall be laid with a minimum slope of 100 mm per 30 m. Depending on the contour of the finished grade, the high-point may be at a terminal, a manhole, a handhole, or between manholes or handholes. Short-radius manufactured 90-degree duct bends may be used only for pole or equipment risers, unless specifically indicated as acceptable. The minimum manufactured bend radius shall be 450 mm for ducts of less than 80 mm diameter, and 900 mm for ducts 80 mm or greater in diameter. Otherwise, long sweep bends having a minimum radius of 7.6 m shall be used for a change of direction of more than 5 degrees, either horizontally or vertically. Both curved and straight sections may be used to form long sweep bends, but the maximum curve used shall be 30 degrees and manufactured bends shall be used. Ducts shall be provided with end bells whenever duct lines terminate in manholes or handholes.

3.5.2 Treatment

Ducts shall be kept clean of concrete, dirt, or foreign substances during construction. Field cuts requiring tapers shall be made with proper tools and match factory tapers. A coupling recommended by the duct manufacturer shall be used whenever an existing duct is connected to a duct of different material or shape. Ducts shall be stored to avoid warping and deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Ducts shall be thoroughly cleaned before being laid. Plastic ducts shall be stored on a flat surface and protected from the direct rays of the sun.

3.5.3 Concrete Encasement

Ducts requiring concrete encasements shall comply with NFPA 70, except that electrical duct bank configurations for ducts 150 mm in diameter shall be determined by calculation and as shown on the drawings. The separation between adjacent electric power and communication ducts shall conform to IEEE C2. Duct line encasements shall be monolithic construction. Where a connection is made to a previously poured encasement, the new encasement shall be well bonded or doweled to the existing encasement. The Contractor shall submit proposed bonding method for approval in accordance with the detail drawing portion of paragraph SUBMITTALS. At any point, except railroad and airfield crossings, tops of concrete encasements shall be not less than the cover requirements listed in NFPA 70. At railroad and airfield crossings, duct lines shall be encased with concrete and reinforced as indicated to withstand specified surface loadings. Tops of concrete encasements shall be not less than 1.5 m below tops of rails or airfield paving unless otherwise indicated. Where ducts are jacked under existing pavement, rigid steel conduit will be installed because of its strength. To protect the corrosion-resistant conduit coating, predrilling or installing conduit inside a larger iron pipe sleeve (jack-and-sleeve) is required. For crossings of existing railroads and airfield pavements greater than 15 m in length, the predrilling method or the jack-and-sleeve method will be used. Separators or spacing blocks shall be made of steel, concrete, plastic, or a combination of these materials placed not farther apart than 1.2 m on centers. Ducts shall be securely anchored to prevent movement during the placement of concrete and joints shall be staggered at least 150 mm vertically.

3.5.4 Installation of Couplings

Joints in each type of duct shall be made up in accordance with the manufacturer's recommendations for the particular type of duct and coupling selected and as approved.

3.5.4.1   Plastic Duct

Duct joints shall be made by brushing a plastic solvent cement on insides of plastic coupling fittings and on outsides of duct ends. Each duct and fitting shall then be slipped together with a quick 1/4-turn twist to set the joint tightly.

3.5.5   Duct Line Markers

Duct line markers shall be provided at the ends of long duct line stubouts or for other ducts whose locations are indeterminate because of duct curvature or terminations at completely below-grade structures. In addition to markers, a 0.127 mm (5 mil) brightly colored plastic tape, not less than 75 mm in width and suitably inscribed at not more than 3 m on centers with a continuous metallic backing and a corrosion-resistant 0.0254 mm (1 mil) metallic foil core to permit easy location of the duct line, shall be placed approximately 300 mm below finished grade levels of such lines.

3.6   MANHOLES, HANDHOLES, AND PULLBOXES

3.6.1   General

Manholes shall be constructed approximately where shown. The exact location of each manhole shall be determined after careful consideration has been given to the location of other utilities, grading, and paving. The location of each manhole shall be approved by the Contracting Officer before construction of the manhole is started. Manholes shall be the type noted on the drawings and shall be constructed in accordance with the applicable details as indicated. Top, walls, and bottom shall consist of reinforced concrete. Walls and bottom shall be of monolithic concrete construction. The Contractor may at his option utilize monolithically constructed precast-concrete manholes having the required strength and inside dimensions as required by the drawings or specifications. In paved areas, frames and covers for manhole and handhole entrances in vehicular traffic areas shall be flush with the finished surface of the paving. In unpaved areas, the top of manhole covers shall be approximately 15 mm above the finished grade. Where existing grades that are higher than finished grades are encountered, concrete assemblies designed for the purpose shall be installed to elevate temporarily the manhole cover to existing grade level. All duct lines entering manholes must be installed on compact soil or otherwise supported when entering a manhole to prevent shear stress on the duct at the point of entrance to the manhole. Duct lines entering cast-in-place concrete manholes shall be cast in-place with the manhole. Duct lines entering precast concrete manholes through a precast knockout penetration shall be grouted tight with a portland cement mortar. PVC duct lines entering precast manholes through a PVC endbell shall be solvent welded to the endbell. A cast metal grille-type sump frame and cover shall be installed over the manhole sump. A cable-pulling iron shall be installed in the wall opposite each duct line entrance.

3.6.2   Electric Manholes

Cables shall be securely supported from walls by hot-dip galvanized cable racks with a plastic coating over the galvanizing and equipped with adjustable hooks and insulators. The number of cable racks indicated shall be installed in each manhole and not less than 2 spare hooks shall be installed on each cable rack. Insulators shall be made of high-glazed porcelain. Insulators will not be required on spare hooks.

3.6.3 Communications Manholes

The number of hot-dip galvanized cable racks with a plastic coating over the galvanizing indicated shall be installed in each telephone manhole. Each cable rack shall be provided with 2 cable hooks. Cables for the telephone and communication systems will be installed by others.

3.6.4 Handholes

Handholes shall be located approximately as shown. Handholes shall be of the type noted on the drawings and shall be constructed in accordance with the details shown.

3.6.5 Pullboxes

Pullbox tops shall be flush with sidewalks or curbs or placed 15 mmabove surrounding grades when remote from curbed roadways or sidewalks. Covers shall be marked "Low-Voltage" and provided with 2 lifting eyes and 2 hold-down bolts. Each box shall have a suitable opening for a ground rod. Conduit, cable, ground rod entrances, and unused openings shall be sealed with mortar.

3.6.6 Ground Rods

A ground rod shall be installed at the manholes, handholes and pullboxes. Ground rods shall be driven into the earth before the manhole floor is poured so that approximately 100 mm of the ground rod will extend above the manhole floor. When precast concrete manholes are used, the top of the ground rod may be below the manhole floor and a No. 1/0 AWG ground conductor brought into the manhole through a watertight sleeve in the manhole wall.

3.7 PAD-MOUNTED EQUIPMENT INSTALLATION

Pad-mounted equipment, shall be installed on concrete pads in accordance with the manufacturer's published, standard installation drawings and procedures, except that they shall be modified to meet the requirements of this document. Units shall be installed so that they do not damage equipment or scratch painted or coated surfaces. After installation, surfaces shall be inspected and scratches touched up with a paint or coating provided by the manufacturer especially for this purpose.

3.7.1 Concrete Pads

3.7.1.1 Construction

Concrete pads for pad-mounted electrical equipment shall be poured-in-place. Pads shall be constructed as indicated, except that exact pad dimensions and mounting details are equipment specific and are the responsibility of the Contractor. Tops of concrete pads shall be level and shall project 100 mm above finished paving or grade and sloped to drain. Edges of concrete pads shall have 20 mm chamfer. Conduits for primary, secondary, and grounding conductors shall be set in place prior to placement of concrete pads. Where grounding electrode conductors are installed through concrete pads, PVC conduit sleeves shall be installed through the concrete to provide physical protection. To facilitate cable installation and termination, the concrete pad shall be provided with a rectangular hole below the primary and secondary compartments, sized in accordance with the manufacturer's recommended dimensions. Upon completion of equipment installation the rectangular hole shall be filled with masonry grout.

3.7.1.2 Concrete and Reinforcement

Concrete work shall have minimum 20 MPa compressive strength and comform to the requirements of Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE. Concrete pad reinforcement shall be in accordance with Section 03200 CONCRETE REINFORCEMENT.

3.7.1.3 Sealing

When the installation is complete, the Contractor shall seal all conduit and other entries into the equipment enclosure with an approved sealing compound. Seals shall be of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter.

3.7.2 Padlocks

Padlocks shall be provided for pad-mounted equipment and for each fence gate. Padlocks shall be keyed as directed by the Contracting Officer.

3.8 CONNECTIONS TO BUILDINGS

Cables shall be extended into the various buildings as indicated, and shall be connected to the first applicable termination point in each building. Interfacing with building interior conduit systems shall be at conduit stubouts terminating 1.5 m outside of a building and 900 mm below finished grade as specified and provided under Section 16415 ELECTRICAL WORK, INTERIOR. After installation of cables, conduits shall be sealed with caulking compound to prevent entrance of moisture or gases into buildings.

3.9 GROUNDING

A ground ring consisting of the indicated configuration of bare copper conductors and driven ground rods shall be installed around pad-mounted equipment as shown. Equipment frames of metal-enclosed equipment, and other noncurrent-carrying metal parts, such as cable shields, cable sheaths and armor, and metallic conduit shall be grounded. At least 2 connections shall be provided from a transformer to the ground ring. Metallic frames and covers of handholes and pull boxes shall be grounded by use of a braided, copper ground strap with equivalent ampacity of No. 6 AWG.

3.9.1 Grounding Electrodes

Grounding electrodes shall be installed as shown on the drawings and as follows:

a. Driven rod electrodes - Unless otherwise indicated, ground rods shall be driven into the earth until the tops of the rods are approximately 300 mm below finished grade.

b. Ground ring - A ground ring shall be installed as shown consisting of bare copper conductors installed 300 mm, plus or minus 75 mm, below finished top of soil grade. Ground ring conductors shall be No. 4/0AWG, minimum.

c. Additional electrodes - When the required ground resistance is not met, additional electrodes shall be provided interconnected with grounding conductors to achieve the specified ground resistance. The additional electrodes will be up to three, 3m rods spaced a minimum of 3m apart a single extension-type rod, 15.9 19.1mm diameter, up to 9.1 m long, driven perpendicular to grade. In high ground resistance, UL listed chemically charged ground rods may be used. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, the Contracting Officer shall be notified immediately.

3.9.2 Grounding and Bonding Connections

Connections above grade shall be made by the fusion-welding process or with bolted solderless connectors, in compliance with UL 467, and those below grade shall be made by a fusion-welding process. Where grounding conductors are connected to aluminum-composition conductors, specially treated or lined copper-to-aluminum connectors suitable for this purpose shall be used.

3.9.3 Grounding and Bonding Conductors

Grounding and bonding conductors include conductors used to bond transformer enclosures and equipment frames to the grounding electrode system. Grounding and bonding conductors shall be sized as shown, and located to provide maximum physical protection. Bends greater than 45 degrees in ground conductors are not permitted. Routing of ground conductors through concrete shall be avoided. When concrete penetration is necessary, nonmetallic conduit shall be cast flush with the points of concrete entrance and exit so as to provide an opening for the ground conductor, and the opening shall be sealed with a suitable compound after installation.

3.9.4 Surge Arrester Grounding

Surge arresters and neutrals shall be bonded directly to the transformer enclosure and then to the grounding electrode system with a bare copper conductor, sized as shown. Lead lengths shall be kept as short as practicable with no kinks or sharp bends.

3.9.5 Manhole, Handhole, or Concrete Pullbox Grounding

Ground rods installed in manholes, handholes, or concrete pullboxes shall be connected to cable racks, cable-pulling irons, the cable shielding, metallic sheath, and armor at each cable joint or splice by means of a No. 4 AWG braided tinned copper wire. Connections to metallic cable sheaths shall be by means of tinned terminals soldered to ground wires and to cable sheaths. Care shall be taken in soldering not to damage metallic cable sheaths or shields. Ground rods shall be protected with a double wrapping of pressure-sensitive plastic tape for a distance of 50 mm above and 150 mm below concrete penetrations. Grounding electrode conductors shall be neatly and firmly attached to manhole or handhole walls and the amount of exposed bare wire shall be held to a minimum.

3.9.6 Metal Splice Case Grounding

Metal splice cases for medium-voltage direct-burial cable shall be grounded by connection to a driven ground rod located within 600 mm of each splice box using a grounding electrode conductor having a current-carrying capacity of at least 20 percent of the individual phase conductors in the associated splice box, but not less than No. 6 AWG.

3.10 FIELD TESTING

3.10.1 General

Field testing shall be performed in the presence of the Contracting Officer. The Contractor shall notify the Contracting Officer 7 days prior to conducting tests. The Contractor shall furnish all materials, labor, and equipment necessary to conduct field tests. The Contractor shall perform all tests and inspections recommended by the manufacturer unless specifically waived by the Contracting Officer. The Contractor shall maintain a written record of all tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results. Field test reports shall be signed and dated by the Contractor.

3.10.2 Safety

The Contractor shall provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. The Contractor shall replace any devices or equipment which are damaged due to improper test procedures or handling.

3.10.3 Ground-Resistance Tests

The resistance of each grounding electrode and the ground ring shall be measured using the fall-of-potential method defined in IEEE Std 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.

a. Single rod electrode - 25 ohms.

b. Multiple rod electrodes - 5 ohms.

d. Ground ring - 5 ohms.

3.10.4 Liquid-Filled Transformer Tests

The following field tests shall be performed on all liquid-filled transformers. Pass-fail criteria shall be in accordance with transformer manufacturer's specifications.

a. Insulation resistance test phase-to-ground.

b. Turns ratio test.

c. Correct phase sequence.

d. Correct operation of tap changer.

3.10.5 Pre-Energization Services

Calibration, testing, adjustment, and placing into service of the installation shall be accomplished by a manufacturer's product field service engineer or independent testing company with a minimum of 2 years of current product experience. The following services shall be performed on the equipment listed below. These services shall be performed subsequent to testing but prior to the initial energization. The equipment shall be inspected to ensure that installation is in compliance with the recommendations of the manufacturer and as shown on the detail drawings. Terminations of conductors at major equipment shall be inspected to ensure the adequacy of connections. Bare and insulated conductors between such terminations shall be inspected to detect possible damage during installation. If factory tests were not performed on completed assemblies, tests shall be performed after the installation of completed assemblies. Components shall be inspected for damage caused during installation or shipment to ensure packaging materials have been removed. Components capable of being both manually and electrically operated shall be operated manually prior to the first electrical operation. Components capable of being calibrated, adjusted, and tested shall be calibrated, adjusted, and tested in accordance with the instructions of the equipment manufacturer. Items for which such services shall be provided, but are not limited to, are the following:

a. Pad-mounted transformers

b. Panelboards

c. Switchboards

d. Metal-enclosed switchgear

e. Busways

f. Switches

3.10.6   Operating Tests

After the installation is completed, and at such times as the Contracting Officer may direct, the Contractor shall conduct operating tests for approval. The equipment shall be demonstrated to operate in accordance with the requirements herein. An operating test report shall be submitted in accordance with paragraph SUBMITTALS.

3.11   MANUFACTURER'S FIELD SERVICE

3.11.1   Onsite Training

The Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total of 8 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance tests. The course instruction shall cover pertinent points involved in operating, starting, stopping, and servicing the equipment, as well as all major elements of the operation and maintenance manuals. Additionally, the course instructions shall demonstrate all routine maintenance operations. A VHS format video tape of the entire training session shall be submitted.

3.11.2   Installation Engineer

After delivery of the equipment, the Contractor shall furnish one or more field engineers, regularly employed by the equipment manufacturer to supervise the installation of the equipment, assist in the performance of the onsite tests, initial operation, and instruct personnel as to the operational and maintenance features of the equipment.

3.12 ACCEPTANCE

Final acceptance of the facility will not be given until the Contractor has successfully completed all tests and after all defects in installation, material or operation have been corrected.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 16 - ELECTRICAL

SECTION 16410

AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH

05/99

-- End of Section Table of Contents --

SECTION 16410

AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH
05/99

PART 1   GENERAL

1.1   REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B 117	(1997) Operating Salt Spray (Fog) Apparatus

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C37.13	(1990; R 1995) Low-Voltage AC Power Circuit Breakers Used in Enclosures
IEEE C37.90.1	(1989; R 1991) IEEE Standard Surge Withstanding Capability (SWC) Tests for Protective Relays and Relay Systems
IEEE C62.41	(1991; R 1995) Surge Voltages in Low-Voltage AC Power Circuits
IEEE Std 602	(1996) Recommended Practices for Electric Systems in Health Care Facilities

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 1	(1993) Industrial Controls and Systems
NEMA ICS 2	(1993) Industrial Control Devices, Controllers and Assemblies
NEMA ICS 4	(1993) Industrial Control and Systems Terminal Blocks
NEMA ICS 6	(1993) Industrial Control and Systems, Enclosures
NEMA ICS 10	(1993) Industrial Control and Systems: AC Transfer Switch Equipment

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1999) National Electrical Code
NFPA 110	(1999) Emergency and Standby Power Systems

UNDERWRITERS LABORATORIES (UL)

UL 1008	(1996; Rev Sep 1997) Transfer Switch Equipment
UL 1066	(1997) Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

*8

SD-02 Shop Drawings

Switches; G, RE~~AE~~

Schematic, external connection, one-line schematic and wiring diagram of each ATS assembly. Interface equipment connection diagram showing conduit and wiring between ATS and related equipment. Device, nameplate, and item numbers shown in list of equipment and material shall appear on drawings wherever that item appears. Diagrams shall show interlocking provisions and cautionary notes, if any. Operating instructions shall be shown either on one-line diagram or separately. Unless otherwise approved, one-line and elementary or schematic diagrams shall appear on same drawing.

Equipment; G, RE~~AE~~
Installation; G, RE~~AE~~

Dimensioned plans, sections and elevations showing minimum clearances, weights, and conduit entry provisions for each ATS.

SD-03 Product Data

Material~~; G, AE~~
Equipment~~; G, AE~~

List of proposed equipment and material, containing a description of each separate item.

SD-06 Test Reports

Tests; G, RE

A description of proposed field test procedures, including proposed date and steps describing each test, its duration and expected results, not less than 2 weeks prior to test date.

Certified factory and field test reports, within 14 days following completion of tests. Reports shall be certified and dated and shall demonstrate that tests were successfully completed prior to shipment of equipment.

SD-07 Certificates

Equipment; G, RE

Material; G, RE

Certificates of compliance showing evidence of UL listing and conformance with applicable NEMA standards. Such certificates are not required if manufacturer's published data, submitted and approved, reflect UL listing or conformance with applicable NEMA standards.

Switching Equipment; G, RE

Evidence that ATS withstand current rating (WCR) has been coordinated with upstream protective devices as required by UL 1008. Upon request, manufacturer shall also provide notarized letter certifying compliance with requirements of this specification, including withstand current rating.

SD-10 Operation and Maintenance Data

Switching Equipment; G, RE
Instructions; G, RE

Six copies of operating manual outlining step-by-step procedures for system startup, operation, and shutdown. Manual shall include manufacturer's name, model number, service manual, parts list, and brief description of equipment and basic operating features. Manufacturer's spare parts data shall be included with supply source and current cost of recommended spare parts. Six copies of maintenance manual listing routine maintenance, possible breakdowns, repairs, and troubleshooting guide. Manual shall include simplified wiring and control diagrams for system as installed.

1.3 GENERAL REQUIREMENTS

1.3.1 Standard Product

Material and equipment shall be standard products of a manufacturer regularly engaged in manufacturing the products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. The experience use shall include applications in similar circumstances and of same design and rating as specified ATS. Equipment shall be capable of being serviced by a manufacturer-authorized and trained organization that is, in the Contracting Officer's opinion, reasonably convenient to the site.

1.3.2 Nameplate

Nameplate showing manufacturer's name and equipment ratings shall be made of corrosion-resistant material with not less than 3 mm tall characters. Nameplate shall be mounted to front of enclosure and shall comply with nameplate requirements of NEMA ICS 2.

1.4 SERVICE CONDITIONS

Seismic requirements shall be as specified in Sections 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT, 15070 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT and 16070 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT as indicated.

PART 2   PRODUCTS

2.1   AUTOMATIC TRANSFER SWITCH (ATS)

ATS shall be electrically operated and mechanically held in both operating positions. ATS shall be suitable for use in emergency systems described in NFPA 70. ATS shall be UL listed. ATS shall be manufactured and tested in accordance with applicable requirements of IEEE C37.90.1, IEEE C37.13, IEEE C62.41, IEEE Std 602, NEMA ICS 1, NEMA ICS 2, NEMA ICS 10, UL 1008 and UL 1066. ATS shall conform to NFPA 110. To facilitate maintenance, manufacturer's instruction manual shall provide typical maximum contact voltage drop readings under specified conditions for use during periodic maintenance. Manufacturer shall provide instructions for determination of contact integrity. ATS shall be rated for continuous duty at specified continuous current rating. ATS shall be fully compatible and approved for use with BP/IS specified. BP/IS shall be considered part of ATS system. ATS shall have following characteristics:

a. Voltage: 480 volts ac.

b. Number of Phases: Three.

c. Number of Wires: Four.

d. Frequency: 60 Hz.

e. Poles: Four switched.

f. ATS WCR: Rated to withstand short-circuit current of 200,000 amperes, RMS symmetrical.

g. Nonwelding Contacts: Rated for nonwelding of contacts when used with upstream feeder overcurrent devices shown and with available fault current specified.

h. Main and Neutral Contacts: Contacts shall have silver alloy composition. Neutral contacts shall have same continuous current rating as main or phase contacts.

2.1.1   Override Time Delay

Time delay to override monitored source deviation shall be adjustable from 0.5 to 6 seconds and factory set at 1 second. ATS shall monitor phase conductors to detect and respond to sustained voltage drop of 25 percent of nominal between any two normal source conductors and initiate transfer action to alternate source and start engine driven generator after set time period. Pickup voltage shall be adjustable from 85 to 100 percent of nominal and factory set at 90 percent. Dropout voltage shall be adjustable from 75 to 98 percent of pickup value and factory set at 85 percent of nominal.

2.1.2   Transfer Time Delay

Time delay before transfer to emergency power source shall be adjustable from 0 to 5 minutes and factory set at 0 minutes. ATS shall monitor frequency and voltage of emergency power source and transfer when frequency and voltage are stabilized. Pickup voltage shall be adjustable from 85 to 100 percent of nominal and factory set at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal and factory set at 90 percent.

2.1.3 Return Time Delay

Time delay before return transfer to normal power source shall be adjustable from 0 to 30 minutes and factory set at 30 minutes. Time delay shall be automatically defeated upon loss or sustained undervoltage of emergency power source, provided that normal supply has been restored.

2.1.4 Engine Shutdown Time Delay

Time delay shall be adjustable from 0 to 30 minutes and shall be factory set at 10 minutes.

2.1.5 Exerciser

Provide a generator exerciser timer. Run times shall be user programmable. The generator exerciser shall be selectable between load transfer and engine run only, and shall have a fail-safe feature that will retransfer the ATS to normal during the exercise period.

2.1.6 Auxiliary Contacts

Two normally open and two normally closed auxiliary contacts rated at 10 amperes at 120 volts shall operate when ATS is connected to normal power source, and two normally open and two normally closed contacts shall operate when ATS is connected to emergency source.

2.1.7 Supplemental Features

ATS shall be furnished with the following:

a. Engine start contact.

b. Emergency source monitor.

c. Test switch to simulate normal power outage.

d. Voltage sensing. Pickup voltage adjustable from 85 to 100 percent of nominal; dropout adjustable from 75 to 98 percent of pickup.

e. Time delay bypass switch to override return time delay to normal.

f. Manual return-to-normal switch.

g. Means shall be provided in the ATS to insure that motor/transformer load inrush currents do not exceed normal starting currents. This shall be accomplished with either in-phase monitoring, time-delay transition, or load voltage decay sensing methods. If manufacturer supplies an in-phase monitoring system, the manufacturer shall indicate under what conditions a transfer cannot be accomplished. If the manufacturer supplies a time-delay transition system, the manufacturer shall supply recommendations for establishing time delay. If load voltage decay sensing is supplied, the load voltage setting shall be user programmable.

2.1.8 Operator

Manual operator conforming to UL 1008 shall be provided, and shall incorporate features to prevent operation by unauthorized personnel. ATS shall be designed for safe manual operation under full load conditions. If manual operation is accomplished by opening the door, then a dead-front shall be supplied for operator safety.

2.1.9 Override Switch

Override switch shall bypass automatic transfer controls so ATS will transfer and remain connected to emergency power source, regardless of condition of normal source.

2.1.10 Green Indicating Light

A green indicating light shall supervise/provide normal power source switch position indication and shall have a nameplate engraved NORMAL.

2.1.11 Red Indicating Light

A red indicating light shall supervise/provide emergency power source switch position indication and shall have a nameplate engraved EMERGENCY.

2.2 BY-PASS/ISOLATION SWITCH (BP/IS)

2.2.1 Design

Bypass/isolation switch (BP/IS) shall permit load by-pass to either normal or emergency power source and complete isolation of associated ATS, independent of ATS operating position. BP/IS and associated ATS shall be products of same manufacturer and shall be completely interconnected and tested at factory and at project site as specified. BP/IS shall be manufactured, listed, and tested in accordance with paragraph AUTOMATIC TRANSFER SWITCH (ATS) and shall have electrical ratings that exceed or equal comparable ratings specified for ATS. Operating handles shall be externally operated and arranged so that one person can perform the bypass and isolation functions through the operation of a maximum of two handles within 5 seconds. The ATS shall have provisions for locking in the isolation position. Handle for manual operation shall be permanently attached to operating mechanism. BP/IS operation shall be accomplished without disconnecting switch load terminal conductors. Isolation handle positions shall be marked with engraved plates or other approved means to indicate position or operating condition of associated ATS, as follows:

a. Indication shall be provided to show that ATS section is providing power to the load.

b. Indication shall be provided of ATS isolation. The ATS controls shall remain functional with the ATS isolated or in bypass mode to permit monitoring of the normal power source and automatic starting of the generator in the event of a loss of the normal power source. In the isolated mode, the bypass section shall be capable of functioning as a manual transfer switch to transfer the load to either power source. The ATS shall be capable of undergoing functional operation testing without service interruption. The ATS may also be completely removed from the enclosure, if required for maintenance or repair, while the bypass section continues to power the load.

2.2.2 Switch Construction

Bypass/isolation switch shall be constructed for convenient removal of parts from front of switch enclosure without removal of other parts or disconnection of external power conductors. Contacts shall be as specified for associated ATS, including provisions for inspection of contacts without disassembly of BP/IS or removal of entire contact enclosure. To facilitate maintenance, manufacturer shall provide instructions for determination of contact integrity. BP/IS and associated ATS shall be interconnected with suitably sized copper bus bars silver-plated at each connection point, and braced to withstand magnetic and thermal forces created at WCR specified for associated ATS.

2.3   ENCLOSURE

ATS and accessories shall be installed in wall-mounted, ventilated NEMA ICS 6, Type 1, smooth sheet metal enclosure constructed in accordance with applicable requirements of UL 1066 and/or UL 1008. Metal gauge shall be not less than No. 14. Enclosure shall be equipped with at least two approved grounding lugs for grounding enclosure to facility ground system using No. 4 AWG copper conductors. Factory wiring within enclosure and field wiring terminating within enclosure shall comply with NFPA 70. If wiring is not color coded, wire shall be permanently tagged or marked near terminal at each end with wire number shown on approved detail drawing. Terminal block shall conform to NEMA ICS 4. Terminals shall be arranged for entrance of external conductors from top and bottom of enclosure as shown. Main switch terminals, including neutral terminal if used, shall be pressure type suitable for termination of external copper conductors shown.

2.3.1   Construction

Enclosure shall be constructed for ease of removal and replacement of ATS components and control devices from front without disconnection of external power conductors or removal or disassembly of major components. Enclosure of ATS with BP/IS shall be constructed to protect personnel from energized BP/IS components during ATS maintenance.

2.3.2   Cleaning and Painting

Both the inside and outside surfaces of an enclosure, including means for fastening, shall be protected against corrosion by enameling, galvanizing, plating, powder coating, or other equivalent means. Protection is not required for metal parts that are inherently resistant to corrosion, bearings, sliding surfaces of hinges, or other parts where such protection is impractical. Finish shall be manufacturer's standard material, process, and color and shall be free from runs, sags, peeling, or other defects. An enclosure marked Type 1, 3R, 4 or 12 shall be acceptable if there is no visible rust at the conclusion of a salt spray (fog) test using the test method in ASTM B 117, employing a 5 percent by weight, salt solution for 24 hours. Type 4X enclosures are acceptable following performance of the above test with an exposure time of 200 hours.

2.4   TESTING

2.4.1   Factory Testing

A prototype of specified ATS shall be factory tested in accordance with UL 1008. In addition, factory tests shall be performed on each ATS as follows:

a. Insulation resistance test to ensure integrity and continuity of entire system.

b. Main switch contact resistance test.

c. Visual inspection to verify that each ATS is as specified.

d. Mechanical test to verify that ATS sections are free of mechanical hindrances.

e. Electrical tests to verify complete system electrical operation and to set up time delays and voltage sensing settings.

2.4.2 Factory Test Reports

Manufacturer shall provide three certified copies of factory test reports.

2.5 SEQUENCE OF OPERATION - LOSS OF NORMAL POWER

1. When the voltage on any phase of the normal source drops below 80% or increases to 120%, or frequency drops below 90%, or increase to 110%, or 20% voltage differential between phases occurs, after a programmable time delay period of 0-9999 seconds factory set at 3 seconds to allow for momentary dips, the engine starting contacts shall close to start the generating plant.

2. The transfer switch shall transfer to emergency when the generating plant has reached specified voltage and frequency on all phases. This operation shall be accomplished in an open transition mode.

3. After restoration of normal power on all phases to a preset value of at least 90% to 110% of rated voltage, and at least 95% to 105% of rated frequency, and voltage differential is below 20%, an adjustable time delay retransfer to allow stabilization of normal power. If the emergency power source should fail during this time delay period, the switch shall automatically return to the normal source, open transition.

4. Retransfer shall be accomplished in a closed transition mode. A synch check relay shall monitor the normal and emergency sources. When both sources are within the proper window of synchronization closed transition retransfer to the normal shall occur. This closed transition period shall not exceed 100 milliseconds. If the switch remains in the closed to normal and emergency position for longer than 100 milliseconds a signal will be sent to shunt trip the normal breaker.

5. After retransfer to normal, the engine generator shall be allowed to operate at no load for a programmable period of 0-9999 seconds, factory set at 300 seconds.

PART 3 EXECUTION

3.1 INSTALLATION

ATS shall be installed as shown and in accordance with approved manufacturer's instructions.

3.2 INSTRUCTIONS

Manufacturer's approved operating instructions shall be permanently secured to cabinet where operator can see them. One-line and elementary or schematic diagram shall be permanently secured to inside of front enclosure door.

3.3 SITE TESTING

Following completion of ATS installation and after making proper adjustments and settings, site tests shall be performed in accordance with manufacturer's written instructions to demonstrate that each ATS functions satisfactorily and as specified. Contractor shall advise Contracting Officer not less than 5 working days prior to scheduled date for site testing, and shall provide certified field test reports within 2 calendar weeks following successful completion of site tests. Test reports shall describe adjustments and settings made and site tests performed. Minimum operational tests shall include the following:

a. Insulation resistance shall be tested, both phase-to-phase and phase-to-ground.

b. Power failure of normal source shall be simulated by opening upstream protective device. This test shall be performed a minimum of five times.

c. Power failure of emergency source with normal source available shall be simulated by opening upstream protective device for emergency source. This test shall be performed a minimum of five times.

d. Low phase-to-ground voltage shall be simulated for each phase of normal source.

e. Operation and settings shall be verified for specified ATS features, such as override time delay, transfer time delay, return time delay, engine shutdown time delay, exerciser, auxiliary contacts, and supplemental features.

f. Manual and automatic ATS and BP/IS functions shall be verified.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 16 - ELECTRICAL

SECTION 16415A

ELECTRICAL WORK, INTERIOR

08/96

-- End of Section Table of Contents --

SECTION 16415A

ELECTRICAL WORK, INTERIOR
08/96

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C37.16	(1997) Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors - Preferred Ratings, Related Requirements, and Application Recommendations
ANSI C39.1	(1981; R 1992) Requirements for Electrical Analog Indicating Instruments
ANSI C57.12.50	(1981; R 1989) Ventilated Dry-type Distribution Transformers 1 to 500 kVA, Single-Phase; and 15 to 500 kVA, Three-Phase with High-Voltage 601 to 34 500 Volts, Low-Voltage 120 to 600 Volts
ANSI C78.1	(1991; C78.1a; R 1996) Fluorescent Lamps - Rapid-Start Types - Dimensional and Electrical Characteristics
ANSI C78.20	(1995) Electric Lamps - Characteristics of Incandescent Lamps A, G, PS, and Similar Shapes with E26 Medium Screw Bases
ANSI C78.21	(1995) Physical and Electrical Characteristics - Incandescent Lamps - PAR and R Shapes
ANSI C78.1350	(1990) 400-Watt, 100-Volt, S51 Single-Ended High-Pressure Sodium Lamps
ANSI C78.1351	(1989) 250-Watt, 100-Volt S50 Single-Ended High-Pressure Sodium Lamps
ANSI C78.1352	(1990) 1000-Watt, 250-Volt, S52 Single-Ended High-Pressure Sodium Lamps
ANSI C78.1355	(1989) 150-Watt, 55-Volt S55 High-Pressure Sodium Lamps
ANSI C78.1375	(1996) 400-Watt, M59 Single-Ended Metal-Halide lamps

ANSI C78.1376	(1996) 1000-Watt, M47 Single-Ended Metal-Halide Lamps
ANSI C78.2A	(1991) 18 & 26- Watt, Compact Fluorescent Quad Tube Lamps
ANSI C78.2B	(1992) 9 & 13-Watt, Compact Fluorescent Quad Tube Lamps
ANSI C82.1	(1997) Specifications for Fluorescent Lamp Ballasts
ANSI C82.4	(1992) Ballasts for High-Intensity-Discharge and Low-Pressure Sodium Lamps (Multiple-Supply Type)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B 1	(1995) Hard-Drawn Copper Wire
ASTM B 8	(1999) Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM D 709	(1992; R 1997) Laminated Thermosetting Materials

CODE OF FEDERAL REGULATIONS (CFR)

47 CFR 18	Industrial, Scientific, and Medical Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C37.13	(1990; R 1995) Low-Voltage AC Power Circuit Breakers Used in Enclosures
IEEE C37.20.1	(1993) Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear
IEEE C57.12.00	(1993) IEEE Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.13	(1993) Instrument Transformers
IEEE C62.41	(1991; R 1995) Surge Voltages in Low-Voltage AC Power Circuits
IEEE Std 81	(1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1)
IEEE Std 242	(1986; R 1991) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
IEEE Std 399	(1997) Recommended Practice for Industrial and Commercial Power Systems Analysis

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA AB 1	(1993) Molded Case Circuit Breakers and Molded Case Switches
NEMA FU 1	(1986) Low Voltage Cartridge Fuses
NEMA ICS 1	(1993) Industrial Control and Systems
NEMA ICS 2	(1993) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated Not More Than 2,000 Volts AC or 750 Volts DC
NEMA ICS 3	(1993) Industrial Control and Systems Factory Built Assemblies
NEMA ICS 6	(1993) Industrial Control and Systems Enclosures
NEMA LE 4	(1987) Recessed Luminaires, Ceiling Compatibility
NEMA OS 1	(1996) Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports
NEMA OS 2	(1986; Errata Aug 1986; R 1991) Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports
NEMA PB 1	(1995) Panelboards
NEMA PB 2	(1995) Deadfront Distribution Switchboards
NEMA RN 1	(1989) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA SG 3	(1995) Power Switching Equipment
NEMA ST 20	(1992) Dry-Type Transformers for General Applications
NEMA TC 2	(1990) Electrical Polyvinyl Chloride (PVC) Tubing (EPT) and Conduit (EPC-40 and EPC-80)
NEMA VE 1	(1996) Metal Cable Tray Systems
NEMA WD 1	(1983; R 1989) General Requirements for Wiring Devices
NEMA WD 6	(1988) Wiring Devices - Dimensional Requirements

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1999) National Electrical Code

NFPA 101	(1997; Errata 97-1; TIA 97-1) Life Safety Code

UNDERWRITERS LABORATORIES (UL)

UL 5	(1996) Surface Metal Raceways and Fittings
UL 6	(1997) Rigid Metal Conduit
UL 20	(1995; Rev thru Oct 1998) General-Use Snap Switches
UL 50	(1995; Rev thru Oct 1997) Enclosures for Electrical Equipment
UL 67	(1993; Rev thru Nov 1995) Panelboards
UL 83	(1998) Thermoplastic-Insulated Wires and Cables
UL 98	(1994; R thru Jun 1998) Enclosed and Dead-Front Switches
UL 198B	(1995) Class H Fuses
UL 198C	(1986; Rev thru Feb 1998) High-Interrupting-Capacity Fuses, Current-Limiting Types
UL 198D	(1995) Class K Fuses
UL 198E	(1988; Rev Jul 1988) Class R Fuses
UL 198G	(1988; Rev May 1988) Fuses for Supplementary Overcurrent Protection
UL 198H	(1988; Rev thru Nov 1993) Class T Fuses
UL 198L	(1995; Rev May 1995) D-C Fuses for Industrial Use
UL 467	(1993; Rev thru Aug 1996) Grounding and Bonding Equipment
UL 486A	(1997; Rev thru Dec 1998) Wire Connectors and Soldering Lugs for Use with Copper Conductors
UL 486B	(1997; Rev Jun 1997) Wire Connectors for Use with Aluminum Conductors
UL 486C	(1997; Rev thru Aug 1998) Splicing Wire Connectors
UL 486E	(1994; Rev thru Feb 1997) Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors

UL 489	(1996; Rev thru Dec 1998) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 498	(1996; Rev thru Sep 1998) Attachment Plugs and Receptacles
UL 506	(1994; Rev Oct 1997) Specialty Transformers
UL 508	(1999) Industrial Control Equipment
UL 510	(1994; Rev thru Apr 1998) Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape
UL 512	(1993; R Dec 1995) Fuseholders
UL 514A	(1996; Rev Jul 1998) Metallic Outlet Boxes
UL 514B	(1997; Rev Oct 1998) Fittings for Cable and Conduit
UL 514C	(1996; R Sep 1998) Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 542	(1994; Rev thru Jul 1998) Lampholders, Starters, and Starter Holders for Fluorescent Lamps
UL 651	(1995; Rev thru Oct 1998) Schedule 40 and 80 Rigid PVC Conduit
UL 651A	(1995; Rev thru Apr 1998) Type EB and A Rigid PVC Conduit and HDPE Conduit
UL 698	(1999)) Industrial Control Equipment for Use in Hazardous (Classified) Locations
UL 797	(1993; Rev thru Mar 1997) Electrical Metallic Tubing
UL 844	(1995; Rev thru Aug 1997) Electric Lighting Fixtures for Use in Hazardous (Classified) Locations
UL 845	(1995; Rev Feb 1996) Motor Control Centers
UL 877	(1993; Rev thru May 1997) Circuit Breakers and Circuit-Breaker Enclosures for Use in Hazardous (Classified) Locations
UL 886	(1994; Rev thru Apr 1999) Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations
UL 891	(1994; Rev thru Jan 1995) Dead-Front Switchboards
UL 916	(1998) Energy Management Equipment

UL 943	(1993; Rev thru May 1998)Ground-Fault Circuit-Interrupters
UL 1010	(1995; Rev thru Dec 1996)Receptacle-Plug Combinations for Use in Hazardous (Classified) Locations
UL 1029	(1994; Rev thru Dec 1997) High-Intensity-Discharge Lamp Ballasts
UL 1449	(1996; Rev thru Oct 1998) Transient Voltage Surge Suppressors
UL 1570	(1995; Rev thru Jun 1997) Fluorescent Lighting Fixtures
UL 1571	(1995; Rev thru Jun 1997) Incandescent Lighting Fixtures
UL 1572	(1995; Rev thru Jun 1997) High Intensity Discharge Lighting Fixtures
UL Elec Const Dir	(1998) Electrical Construction Equipment Directory

1.2 GENERAL

1.2.1 Rules

The installation shall conform to the requirements of NFPA 70 and NFPA 101, unless more stringent requirements are indicated or shown.

1.2.2 Coordination

The drawings indicate the extent and the general location and arrangement of equipment, conduit, and wiring. The Contractor shall become familiar with all details of the work and verify all dimensions in the field so that the outlets and equipment shall be properly located and readily accessible. Lighting fixtures, outlets, and other equipment and materials shall be carefully coordinated with mechanical or structural features prior to installation and positioned according to architectural reflected ceiling plans; otherwise, lighting fixtures shall be symmetrically located according to the room arrangement when uniform illumination is required, or asymmetrically located to suit conditions fixed by design and shown. Raceways, junction and outlet boxes, and lighting fixtures shall not be supported from sheet metal roof decks. If any conflicts occur necessitating departures from the drawings, details of and reasons for departures shall be submitted and approved prior to implementing any change. The Contractor shall coordinate the electrical requirements of the mechanical work and provide all power related circuits, wiring, hardware and structural support, even if not shown on the drawings.

1.2.3 Special Environments

1.2.3.1 Weatherproof Locations

Wiring, Fixtures, and equipment in designated locations shall conform to NFPA 70 requirements for installation in damp or wet locations.

1.2.3.2 Hazardous Locations

Wiring in locations indicated shall conform to the NFPA 70 for Class I, Division 2 hazardous locations. Wiring and equipment in locations indicated shall be of the classes, groups, divisions, and suitable for the operating temperature; as indicated.

1.2.3.3 Ducts, Plenums and Other Air-Handling Spaces

Wiring and equipment in ducts, plenums and other air-handling spaces shall be installed using materials and methods in conformance with NFPA 70unless more stringent requirements are indicated in this specification or on the contract drawings.

1.2.4 Standard Products

Material and equipment shall be a standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

1.2.5 Nameplates

1.2.5.1 Identification Nameplates

Major items of electrical equipment and major components shall be permanently marked with an identification name to identify the equipment by type or function and specific unit number as indicated. Designation of motors shall coincide with their designation in the motor control center or panel. Unless otherwise specified, identification nameplates shall be made of laminated plastic in accordance with ASTM D 709 with black outer layers and a white core. Edges shall be chamfered. Plates shall be fastened with black-finished round-head drive screws, except motors, or approved nonadhesive metal fasteners. When the nameplate is to be installed on an irregular-shaped object, the Contractor shall devise an approved support suitable for the application and ensure the proper installation of the supports and nameplates. In all instances, the nameplate shall be installed in a conspicuous location. At the option of the Contractor, the equipment manufacturer's standard embossed nameplate material with black paint-filled letters may be furnished in lieu of laminated plastic. The front of each panelboard, motor control center, switchgear, and switchboard shall have a nameplate to indicate the phase letter, corresponding color and arrangement of the phase conductors. The following equipment, as a minimum, shall be provided with identification nameplates:

Minimum 6.4 mm High Letters	Minimum 3.2 mm High Letters
Panelboards	Control Power Transformers
Starters	Control Devices
Safety Switches	Instrument Transformers
Motor Control Centers	
Transformers	
Equipment Enclosures	
Switchgear	
Switchboards	
Motors	

Each panel, section, or unit in motor control centers, switchgear or similar assemblies shall be provided with a nameplate in addition to nameplates listed above, which shall be provided for individual compartments in the respective assembly, including nameplates which identify "future," "spare," and "dedicated" or "equipped spaces."

1.2.5.2   Liquid-Filled Transformer Nameplates

Power transformers shall be provided with Nameplate C information in accordance with IEEE C57.12.00. Nameplates shall indicate percent impedance, voltage, kVA, frequency, number of phases, cooling class, insulation class, temperature rise, the number of gallons and composition of liquid-dielectric, and shall be permanently marked with a statement that the transformer dielectric to be supplied is non-polychlorinated biphenyl. The Contractor shall furnish manufacturer's certification for each transformer that the dielectric is non-PCB classified, with less than 50 ppm PCB content in accordance with paragraph LIQUID DIELECTRICS. Certifications shall be related to serial numbers on transformer nameplates. Transformer dielectric exceeding the 50fs2 ppm PCB content or transformers without certification will be considered as PCB insulated and will not be accepted.

1.2.6   As-Built Drawings

Following the project completion or turnover, within 30 days the Contractor shall furnish 2 sets of as-built drawings to the Contracting Officer.

1.2.7   Recessed Light Fixtures (RLF) Option

The Contractor has the option to substitute inch-pound (I-P) RLF to metric RLF. This option shall be coordinated with Section 09510 ACOUSTICAL CEILINGS.

1.3   SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

*8

SD-02 Shop Drawings

Interior Electrical Equipment; G, RE~~AE~~

Detail drawings consisting of equipment drawings, illustrations, schedules, instructions, diagrams, and other information necessary to define the installation. Detail drawings shall show the rating of items and systems and how the components of an item and system are assembled, function together, and how they will be installed on the project. Data and drawings for component parts of an item or system shall be coordinated and submitted as a unit. Data and drawings shall be coordinated and included in a single submission. Multiple submissions for the same equipment or system are not acceptable except where prior approval has been obtained from the Contracting Officer. In such cases, a list of data to be submitted later shall be included with the first submission. Detail drawings shall show physical arrangement, construction details, connections, finishes, materials used in fabrication, provisions for conduit or busway entrance, access requirements for installation and maintenance, physical size, electrical characteristics, foundation and support details, and equipment weight. Drawings shall be drawn to scale and/or dimensioned. Optional items shall be clearly identified as included or excluded. Detail drawings shall as a minimum include:

a. Transformers.

b. Switchgear.

c. Motor control centers.

d. Single line electrical diagrams including primary, metering, sensing and relaying, control wiring, and control logic.

e. Sway bracing for suspended luminaires.

Structural drawings showing the structural or physical features of major equipment items, components, assemblies, and structures, including foundations or other types of supports for equipment and conductors. These drawings shall include accurately scaled or dimensioned outline and arrangement or layout drawings to show the physical size of equipment and components and the relative arrangement and physical connection of related components. Weights of equipment, components and assemblies shall be provided when required to verify the adequacy of design and proposed construction of foundations or other types of supports. Dynamic forces shall be stated for switching devices when such forces must be considered in the design of support structures. The appropriate detail drawings shall show the provisions for leveling, anchoring, and connecting all items during installation, and shall include any recommendations made by the manufacturer.

Electrical drawings including single-line and three-line diagrams, and schematics or elementary diagrams of each electrical system; internal wiring and field connection diagrams of each electrical device when published by the manufacturer; wiring diagrams of cabinets, panels, units, or separate mountings; interconnection diagrams that show the wiring between separate components of assemblies; field connection diagrams that show the termination of wiring routed between separate items of equipment; internal wiring diagrams of equipment showing wiring as actually provided for this project. Field wiring connections shall be clearly identified.

If departures from the contract drawings are deemed necessary by the Contractor, complete details of such departures, including changes in related portions of the project and the reasons why, shall be submitted with the detail drawings. Approved departures shall be made at no additional cost to the Government.

SD-03 Product Data

Fault Current and Protective Device Coordination Study; G, AE

The study shall be submitted along with protective device equipment submittals. No time extensions or similar contract modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed shall be based on recommendations of this study, The Government shall not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study.

Manufacturer's Catalog~~; G, AE~~

Data composed of catalog cuts, brochures, circulars, specifications, product data, and printed information in sufficient detail and scope to verify compliance with the requirements of the contract documents.

Material, Equipment, and Fixture Lists~~; G, AE~~

A complete itemized listing of equipment and materials proposed for incorporation into the work. Each entry shall include an item number, the quantity of items proposed, and the name of the manufacturer of each item.

Installation Procedures~~; G, AE~~

Installation procedures for rotating equipment, transformers, switchgear, battery systems. Procedures shall include diagrams, instructions, and precautions required to install, adjust, calibrate, and test devices and equipment.

As-Built Drawings; G, RE

The as-built drawings shall be a record of the construction as installed. The drawings shall include all the information shown on the contract drawings, deviations, modifications, and changes from the contract drawings, however minor. The as-built drawings shall be kept at the job site and updated daily. The as-built drawings shall be a full-sized set of prints marked to reflect all deviations, changes, and modifications. The as-built drawings shall be complete and show the location, size, dimensions, part identification, and other information. Additional sheets may be added. The as-built drawings shall be jointly inspected for accuracy and completeness by the Contractor's quality control representative and by the Contracting Officer prior to the submission of each monthly pay estimate. Upon completion of the work, the Contractor shall submit three full sized sets of the marked prints to the Contracting Officer for approval. If upon review, the as-built drawings are found to contain errors and/or omissions, they will be returned to the Contractor for correction. The Contractor shall correct and return the as-built drawings to the Contracting Officer for approval within ten calendar days from the time the drawings are returned to the Contractor.

Onsite Tests; G, RE

A detailed description of the Contractor's proposed procedures for on-site tests.

SD-06 Test Reports

Factory Test Reports; G, RE

Six copies of the information described below in 216 x 280 mm binders having a minimum of 5 rings from which material may readily be removed and replaced, including a separate section for each test. Sections shall be separated by heavy plastic dividers with tabs.

a. A list of equipment used, with calibration certifications.

b. A copy of measurements taken.

c. The dates of testing.

d. The equipment and values to be verified.

e. The conditions specified for the test.

f. The test results, signed and dated.

g. A description of adjustments made.

Field Test Plan; G, RE

A detailed description of the Contractor's proposed procedures for onsite test submitted 20 days prior to testing the installed system. No field test will be performed until the test plan is approved. The test plan shall consist of complete field test procedures including tests to be performed, test equipment required, and tolerance limits.

Field Test Reports; G, RE

Six copies of the information described below in 216 x 280 mm binders having a minimum of 5 rings from which material may readily be removed and replaced, including a separate section for each test. Sections shall be separated by heavy plastic dividers with tabs.

a. A list of equipment used, with calibration certifications.

b. A copy of measurements taken.

c. The dates of testing.

d. The equipment and values to be verified.

e. The conditions specified for the test.

f. The test results, signed and dated.

g. A description of adjustments made.

h. Final position of controls and device settings.

SD-07 Certificates

Materials and Equipment; G, RE

The label or listing of the Underwriters Laboratories, Inc., will be accepted as evidence that the materials or equipment conform to the applicable standards of that agency. In lieu of this label or listing, a statement from a nationally recognized, adequately equipped testing agency indicating that the items have been tested in accordance with required procedures and that the materials and equipment comply with all contract requirements will be accepted. However, materials and equipment installed in hazardous locations must bear the UL label unless the data submitted from other testing agency is specifically approved in writing by the Contracting Officer. Items which are required to be listed and labeled in accordance with Underwriters Laboratories must be affixed with a UL label that states that it is UL listed. No exceptions or waivers will be granted to this requirement. Materials and equipment will be approved based on the manufacturer's published data.

For other than equipment and materials specified to conform to UL publications, a manufacturer's statement indicating complete compliance with the applicable standard of the American Society for Testing and Materials, National Electrical Manufacturers Association, or other commercial standard, is acceptable.

1.4 WORKMANSHIP

Materials and equipment shall be installed in accordance with NFPA 70, recommendations of the manufacturer, and as shown.

1.5 SEISMIC REQUIREMENTS

Seismic details shall conform to Sections 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 16070 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT.

PART 2 PRODUCTS

Products shall conform to the respective publications and other requirements specified below. Materials and equipment not listed below shall be as specified elsewhere in this section. Items of the same classification shall be identical including equipment, assemblies, parts, and components.

2.1 CABLES AND WIRES

Conductors No. 8 AWG and larger diameter shall be stranded. Conductors No. 10 AWG and smaller diameter shall be solid, except that conductors for remote control, alarm, and signal circuits, classes 1, 2, and 3, shall be stranded unless specifically indicated otherwise. Conductor sizes and ampacities shown are based on copper, unless indicated otherwise. All conductors shall be copper.

2.1.1 Equipment Manufacturer Requirements

When manufacturer's equipment requires copper conductors at the terminations or requires copper conductors to be provided between components of equipment, provide copper conductors or splices, splice boxes, and other work required to meet manufacturer's requirements.

2.1.2 Aluminum Conductors

Aluminum conductors shall not be used.

2.1.3   Insulation

Unless indicated otherwise, or required by NFPA 70, power and lighting wires shall be 600-volt, Type THWN, THHN, or THW conforming to UL 83 except that grounding wire may be type TW conforming to UL 83; remote-control and signal circuits shall be Type TW, THW or TF, conforming to UL 83. Where lighting fixtures require 90-degree Centigrade (C) conductors, provide only conductors with 90-degree C insulation or better.

2.1.4   Bonding Conductors

ASTM B 1, solid bare copper wire for sizes No. 8 AWG and smaller diameter; ASTM B 8, Class B, stranded bare copper wire for sizes No. 6 AWG and larger diameter.

2.2   CABLE TRAYS

NEMA VE 1 cable trays shall form a wireway system, and shall be of nominal 100mm depth. Cable trays shall be contructed of aluminum. Trays shall include splice and end plates, dropouts, and miscellaneous hardware. Edges, fittings, and hardware shall be finished free from burrs and sharp edges. Fittings shall have not less than the load-carrying ability of straight tray sections and shall have manufacturer's minimum standard radius. Radius of bends shall be 610mm..The contractor shall provide all required accessories for offisets which are required for mechanical/utility conflicts.

2.2.1   Trough

Trough-type cable trays shall be of a nominal 152 mm or 600 mm width. Refer to drawings for locations.

2.3   TRANSIENT VOLTAGE SURGE PROTECTION

Transient voltage surge suppressors shall be provided as indicated. Surge suppressors shall meet the requirements of IEEE C62.41 and be UL listed and labeled as having been tested in accordance with UL 1449. Surge suppressor ratings shall be as indicated 1,000 volts rms, operating voltage; 60 Hz; 3-phase; 4 wire with ground; transient suppression voltage (peak let-through voltage) of 2,500 voltstrike. Fuses shall not be used as surge suppression.

2.4   CIRCUIT BREAKERS

2.4.1   MOLDED-CASE CIRCUIT BREAKERS

Molded-case circuit breakers shall conform to NEMA AB 1 and UL 489and UL 877 for circuit breakers and circuit breaker enclosures located in hazardous (classified) locations. Circuit breakers may be installed in panelboards, switchboards, enclosures, motor control centers, or combination motor controllers.

2.4.1.1   Construction

Circuit breakers shall be suitable for mounting and operating in any position. Lug shall be listed for copper conductors only in accordance with UL 486E. Single-pole circuit breakers shall be full module size with not more than one pole per module. Multi-pole circuit breakers shall be of the common-trip type having a single operating handle such that an overload or short circuit on any one pole will result in all poles opening simultaneously. Sizes of 100 amperes or less may consist of single-pole breakers permanently factory assembled into a multi-pole unit having an internal, mechanical, nontamperable common-trip mechanism and external handle ties. All circuit breakers shall have a quick-make, quick-break overcenter toggle-type mechanism, and the handle mechanism shall be trip-free to prevent holding the contacts closed against a short-circuit or sustained overload. All circuit breaker handles shall assume a position between "ON" and "OFF" when tripped automatically. All ratings shall be clearly visible.

2.4.1.2 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. The interrupting rating of the circuit breakers shall be at least equal to the available short-circuit current at the line terminals of the circuit breaker and correspond to the UL listed integrated short-circuit current rating specified for the panelboards and switchboards. Molded-case circuit breakers shall have nominal voltage ratings, maximum continuous-current ratings, and maximum short-circuit interrupting ratings in accordance with NEMA AB 1. Ratings shall be coordinated with system X/R ratio.

2.4.1.3 Cascade System Ratings

Circuit breakers used in series combinations shall be in accordance with UL 489. Equipment, such as switchboards and panelboards, which house series-connected circuit breakers shall be clearly marked accordingly. Series combinations shall be listed in the UL Recognized Component Directory under "Circuit Breakers-Series Connected."

2.4.1.4 Thermal-Magnetic Trip Elements

Thermal magnetic circuit breakers shall be provided as shown. Automatic operation shall be obtained by means of thermal-magnetic tripping devices located in each pole providing inverse time delay and instantaneous circuit protection. The instantaneous magnetic trip shall be adjustable and accessible from the front of all circuit breakers on frame sizes above 150 amperes.

2.4.2 Solid-State Trip Elements

Solid-state circuit breakers shall be provided as shown. All electronics shall be self-contained and require no external relaying, power supply, or accessories. Printed circuit cards shall be treated to resist moisture absorption, fungus growth, and signal leakage. All electronics shall be housed in an enclosure which provides protection against arcs, magnetic interference, dust, and other contaminants. Solid-state sensing shall measure true RMS current with error less than one percent on systems with distortions through the 13th harmonic. Peak or average actuating devices are not acceptable. Current sensors shall be torodial construction, encased in a plastic housing filled with epoxy to protect against damage and moisture and shall be integrally mounted on the breaker. Where indicated on the drawings, circuit breaker frames shall be rated for 100 percent continuous duty. Circuit breakers shall have tripping features as shown on the drawings and as described below:

a. Long-time current pick-up, adjustable from 50 percent to 100 percent of continuous current rating.

b. Adjustable long-time delay.

c. Short-time current pick-up, adjustable from 1.5 to 9 times long-time current setting.

d. Adjustable short-time delay.

e. Short-time I square times t switch.

f. Instantaneous current pick-up, adjustable from 1.5 to 9 times long-time current setting.

g. Ground-fault pick-up, adjustable from 20 percent to 60 percent of sensor rating, but not greater than 1200 amperes. Sensing of ground-fault current at the main bonding jumper or ground strap will not be permitted. Zone-selective interlocking shall be provided as shown.

h. Adjustable ground-fault delay.

i. Ground-fault I square times t switch.

j. Overload and short-time and ground-fault trip indicators shall be provided.

2.4.3 Current-Limiting Circuit Breakers

Current-limiting circuit breakers shall be provided as shown. Current-limiting circuit breakers shall limit the let-through I square times t to a value less than the I square times t of one-half cycle of the symmetrical short-circuit current waveform. On fault currents below the threshold of limitation, breakers shall provide conventional overload and short-circuit protection. Integrally-fused circuit breakers shall not be used.

2.4.4 SWD Circuit Breakers

Circuit breakers rated 15 amperes and intended to switch 277 volts or less fluorescent lighting loads shall be marked "SWD."

2.4.5 HACR Circuit Breakers

Circuit breakers 60 amperes or below, 240 volts, 1-pole or 2-pole, intended to protect multi-motor and combination-load installations involved in heating, air conditioning, and refrigerating equipment shall be marked "Listed HACR Type."

2.4.6 Low-Voltage Power

a. Construction:

Low-voltage power circuit breakers shall conform to IEEE C37.13, ANSI C37.16, and NEMA SG 3 and shall be three-pole, single-throw, stored energy, electrically operated, with drawout mounting. Solid-state trip elements which require no external power connections shall be provided. Circuit breakers shall have an open/close contact position indicator, charged/discharged stored energy indicator, primary disconnect devices, and a mechanical interlock to prevent making or breaking contact of the primary disconnects when the circuit breaker is closed. Control voltage shall be 120 V dc. The circuit breaker enclosure shall be suitable for its intended location.

b. Ratings:

Voltage ratings shall be not less than the applicable circuit voltage. Circuit breakers shall be rated for 100 percent continuous duty and shall have trip current ratings and frame sizes as shown. Nominal voltage ratings, maximum continuous-current ratings, and maximum short-circuit interrupting ratings shall be in accordance with ANSI C37.16. Tripping features shall be as follows:

1. Long-time current pick-up, adjustable from 50 percent to 100 percent of sensor current rating.

2. Adjustable long-time delay.

3. Short-time current pick-up, adjustable from 1.5 to 9 times long-time current setting.

4. Adjustable short-time delay.

5. Short-time I square times t switch.

6. Instantaneous current pick-up, adjustable from 1.5 to 9 times long-time current setting.

7. Ground-fault pick-up, adjustable from 20 percent to 60 percent of sensor rating, but in no case greater than 1200 amperes. Sensing of ground-fault current at the main bonding jumper or ground strap shall not be permitted. Zone-selective interlocking shall be provided as shown.

8. Adjustable ground-fault delay.

9. Ground-fault I square times t switch.

10. Overload and short-circuit and ground-fault trip indicators shall be provided.

2.4.7 Ground Fault Circuit Interrupters

UL 943. Breakers equipped with ground fault circuit interrupters shall have ground fault class, interrupting capacity, and voltage and current ratings as indicated.

2.5 CONDUIT AND TUBING

2.5.1 Electrical, Zinc-Coated Steel Metallic Tubing (EMT)

UL 797

2.5.2 Flexible Conduit, Steel

General-purpose type, UL 1; liquid tight, UL 360, and UL 1660.

2.5.3 Rigid Metal Conduit

UL 6.

2.5.4 Rigid Plastic Conduit

NEMA TC 2, UL 651 and UL 651A.

2.5.5 Surface Aluminum Electrical Raceways and Fittings

UL 5.

2.6 CONDUIT AND DEVICE BOXES AND FITTINGS

2.6.1 Boxes, Metallic Outlet

NEMA OS 1 and UL 514A.

2.6.2 Boxes, Nonmetallic, Outlet and Flush-Device Boxes and Covers

NEMA OS 2 and UL 514C.

2.6.3 Boxes, Outlet for Use in Hazardous (Classified) Locations

UL 886.

2.6.4 Boxes, Switch (Enclosed), Surface-Mounted

UL 98.

2.6.5 Fittings for Conduit and Outlet Boxes

UL 514B.

2.6.6 Fittings For Use in Hazardous (Classified) Locations

UL 886.

2.6.7 Fittings, PVC, for Use with Rigid PVC Conduit and Tubing

UL 514B.

2.7 CONDUIT COATINGS PLASTIC RESIN SYSTEM

NEMA RN 1, Type A-40.

2.8 CONNECTORS, WIRE PRESSURE

2.8.1 For Use With Copper Conductors

UL 486A.

2.8.2 For Use With Aluminum Conductors

UL 486B.

*9

2.9 METAL CLAD CABLE

Metal-Clad Cable: Use metal clad armored cable for branch circuits and lighting fixture whips (maximum whip length shall be 900mm) within stud partitions, above accessible ceilings and in interior concealed areas. Metal clad cable for use at 600 volts and below, for lighting circuits shall be multiple insulated copper conductors, protected by an interlocking armor of galvanized steel. Unless otherwise specified, copper conductors shall be soft drawn with NEC Type T, thermoplastic insulation. Metal clad cables shall contain color coded conductors of which one shall be a white neutral conductor and one shall be a green equipment grounding conductor.

2.10 ELECTRICAL GROUNDING AND BONDING EQUIPMENT

UL 467.

2.10.1 Ground Rods

Ground rods shall be of copper-clad steel conforming to UL 467not less than 19.1 mm in diameter by 3.1 meter in length of the sectional type driven full length into the earth.

2.10.2 Ground Bus

The ground bus shall be bare conductor or flat copper in one piece, if practicable.

2.11 ENCLOSURES

NEMA ICS 6 or UL 698 for use in hazardous (classified) locations, unless otherwise specified.

2.11.1 Cabinets and Boxes

Cabinets and boxes with volume greater than 0.0164 cubic meters shall be in accordance with UL 50, hot-dip, zinc-coated, if sheet steel.

2.11.2 Circuit Breaker Enclosures

UL 489.

2.11.3 Circuit Breaker Enclosures for Use in Hazardous (Classified) Locations

UL 877.

2.12 LIGHTING FIXTURES, LAMPS, BALLASTS, EMERGENCY EQUIPMENT, CONTROLS AND ACCESSORIES

The following specifications are supported and supplemented by information and details on the drawings. Additional fixtures, if shown, shall conform to this specification. Lighting equipment installed in classified hazardous locations shall conform to UL 844. Lamps, lampholders, ballasts, transformers, electronic circuitry and other lighting system components shall be constructed according to industry standards. Equipment shall be tested and listed by a recognized independent testing laboratory for the expected installation conditions. Equipment shall conform to the standards listed below.

2.12.1 Lamps

Lamps shall be constructed to operate in the specified fixture, and shall function without derating life or output as listed in published data.

Lamps shall meet the requirements of the Energy Policy Act of 1992. All compact and linear fluorescent lamps shall be low mercury content certified to pass the U.S. Environmental Protection Agency (EPA) Toxic Characteristics Leaching Procedure (TCLP) test for non-hazardous waste.

a. Incandescent and tungsten halogen lamps shall be designed for 125 volt operation (except for low voltage lamps), shall be rated for minimum life of 2,000 hours, and shall have color temperature between 2,800 and 3,200 degrees Kelvin. Tungsten halogen lamps shall incorporate quartz capsule construction. Lamps shall comply with ANSI C78.20 and sections 238 and 270 of ANSI C78.21.

b. Fluorescent lamps shall have color temperature as shown. They shall be designed to operate with the ballasts and circuitry of the fixtures in which they will be used. Fluorescent lamps, including spares, shall be manufactured by one manufacturer to provide for color and performance consistency. Fluorescent lamps shall comply with ANSI C78.1. Fluorescent tube lamp efficiencies shall meet or exceed the following requirements.

T8, 32 watts	(4' lamp)	2800 lumens
T12,34 watts	(4' lamp)	2800 lumens
T8,59 watts	(8' lamp)	5700 lumens
T12,60 watts	(8' lamp)	5600 lumens
T8/U,31-32 watts	(U-tube)	2600 lumens
T12/U,34 watts	(U-tube)	2700 lumens

(1) Linear fluorescent lamps, unless otherwise indicated, shall be 1219 mm long 32 watt T8, 265 mA, with minimum CRI of 75. Lamps of other lengths or types shall be used only where specified or shown. Lamps shall deliver rated life when operated on instant start ballasts.

(2) Small compact fluorescent lamps shall be twin, double, or triple tube configuration as shown with bi-pin or four-pin snap-in base and shall have minimum CRI of 85. They shall deliver rated life when operated on ballasts as shown. 9 and 13 watt double tube lamps shall comply with ANSI C78.2B. 18 and 26 watt double tube lamps shall comply with ANSI C78.2A. Minimum starting temperature shall be 0 degrees C for twin tube lamps and for double and triple twin tube lamps without internal starter; and -9 degrees C for double and triple twin tube lamps with internal starter.

(3) Long compact fluorescent lamps shall be 18, 27, 39, 40, 50, or 55 watt bi-axial type as shown with four-pin snap-in base; shall have minimum CRI of 85; and shall have a minimum starting temperature of 10 degrees C . They shall deliver rated life when operated on instant start ballasts.

c. High intensity discharge lamps, including spares, shall be manufactured by one manufacturer in order to provide color and performance consistency. High intensity discharge lamps shall be designed to operate with the ballasts and circuitry of the fixtures in which they will be used and shall have wattage, shape and base as shown. High intensity discharge lamps, unless otherwise shown, shall have medium or mogul screw base and minimum starting temperature of -29 degrees C . Metal halide lamps, unless otherwise shown, shall have minimum CRI of 65; color temperature of 4,300 degrees Kelvin; shall be -BU configuration if used in base-up position; and shall be -H or high output configuration if used in horizontal position. Lamps shall comply with all applicable ANSI C78.1350, ANSI C78.1351, ANSI C78.1352, ANSI C78.1355,ANSI C78.1375, and ANSI C78.1376.

2.12.2 Ballasts and Transformers

Ballasts or transformers shall be designed to operate the designated lamps within their optimum specifications, without derating the lamps. Lamp and ballast combinations shall be certified as acceptable by the lamp manufacturer.

a. Low voltage incandescent transformers shall be Class II UL listed 120/12 volt or 120/24 volt step-down transformers as required for the lamps shown. Transformers shall be high power factor type and shall be rated for continuous operation under the specified load. Transformers shall be encased or encased and potted, and mounted integrally within the lighting fixture unless otherwise shown.

b. Fluorescent ballasts shall comply with ANSI C82.1 and shall be mounted integrally within fluorescent fixture housing unless otherwise shown. Ballasts shall have maximum current crest factor of 1.7; high power factor; Class A sound rating; maximum operating case temperature of 25 degrees C above ambient; and shall be rated Class P. Unless otherwise indicated, the minimum number of ballasts shall be used to serve each individual fixture. A single ballast may be used to serve multiple fixtures if they are continuously mounted, identically controlled and factory manufactured for that installation with an integral wireway.

(1) Compact fluorescent ballasts shall comply with IEEE C62.41 Category A transient voltage variation requirements and shall be mounted integrally within compact fluorescent fixture housing unless otherwise shown. Ballasts shall have minimum ballast factor of 0.95; maximum current crest factor of 1.6; high power factor; maximum operating case temperature of 25 degrees C above ambient; shall be rated Class P; and shall have a sound rating of Class A. Ballasts shall meet FCC Class A specifications for EMI/RFI emissions. Ballasts shall operate from nominal line voltage of 277 volts at 60 Hz and maintain constant light output over a line voltage variation of $\pm$ 10%. Ballasts shall have an end-of-lamp-life detection and shut-down circuit. Ballasts shall be UL listed and shall contain no PCBs. Ballasts shall contain potting to secure PC board, provide lead strain relief, and provide a moisture barrier.

(2) Electronic fluorescent ballasts shall comply with 47 CFR 18 for electromagnetic interference. Ballasts shall withstand line transients per IEEE C62.41, Category A. Ballasts shall have total harmonic distortion between 10 and 20%; minimum frequency of 20,000Hz; filament voltage between 2.5 and 4.5 volts; maximum starting inrush current of 20 amperes; and shall comply with the minimum Ballast Efficacy Factors shown in the table below. Minimum starting temperature shall be as shown. Ballasts shall

carry a manufacturer's full warranty of three years, including a minimum $10 labor allowance per ballast.

ELECTRONIC FLUORESCENT BALLAST EFFICACY FACTORS

LAMP TYPE	TYPE OF STARTER & LAMP	NOMINAL OPERATIONAL VOLTAGE	NUMBER OF LAMPS	MINIMUM BALLAST EFFICACY FACTOR
32W T8	rapid start linear & U-tubes	120 or 277 V	1 2 3 4	2.54 1.44 0.93 0.73
59W T8	rapid start linear	120 or 277 V	2	0.80

(4) Dimming and daylight harvesting fluorescent ballasts shall be electronic and shall comply with the applicable electronic ballast specifications shown above. Dimming ballasts shall be compatible with the specified lighting control system and light level sensors specified under Section 15951 and shall operate the lamps shown in the range from full rated light output to 1 percent of full rated light output. Dimming ballasts shall provide smooth square law dimming such that perceived dimming action is proportionate to the motion of the dimming control. Single or two-lamp dimming ballasts shall be used. Multi-lamp dimming ballasts shall be designed to operate lamps of the same length and current rating.

(5) Dimming and daylight harvesting compact fluorescent ballasts shall be electronic and shall comply with the applicable compact fluorescent and dimming ballast specifications shown above. Ballasts shall operate the lamps shown in the range from full rated light output to 5 percent of full rated light output. Ballast power factor shall be <90% throughout dimming range. THD shall be <10% at maximum light output and <20% at minimum light output. Ballast shall ignite the lamps at any light output setting selected.

c. High intensity discharge ballasts shall comply with UL 1029 and, if multiple supply types, with ANSI C82.4. Ballasts shall have minimum ballast factor of 0.9; high power factor; Class A sound rating; and maximum operating case temperature of 25 degrees C above ambient.

(1) Electronic high intensity discharge ballasts shall be constant wattage autotransformer type; shall have less than 10% ballast loss; shall have total harmonic distortion between 10 and 20%; and shall have a minimum starting temperature of -18 degrees C .

(2) Magnetic high intensity discharge ballasts shall have a minimum starting temperature of -29 degrees C .

2.12.3 Fixtures

Fixtures shall be in accordance with the size, shape, appearance, finish, and performance shown. Unless otherwise indicated, lighting fixtures shall be provided with housings, junction boxes, wiring, lampholders, mounting supports, trim, hardware and accessories for a complete and operable installation. Recessed housings shall be minimum 20 gauge cold rolled or galvanized steel as shown. Extruded aluminum fixtures shall have minimum wall thickness of 3 mm . Plastic lenses shall be 100% virgin acrylic or as shown. Glass lenses shall be tempered. Heat resistant glass shall be borosilicate type. Conoid recessed reflector cones shall be Alzak with clear specular low iridescent finish.

a. Incandescent fixtures shall comply with UL 1571. Incandescent fixture specular reflector cone trims shall be integral to the cone and shall be finished to match. Painted trim finishes shall be white with minimum reflectance of 88%. Low voltage incandescent fixtures shall have integral step-down transformers.

b. Fluorescent fixtures shall comply with UL 1570. Recessed ceiling fixtures shall comply with NEMA LE 4. Fixtures shall be plainly marked for proper lamp and ballast type to identify lamp diameter, wattage, color and start type. Marking shall be readily visible to service personnel, but not visible from normal viewing angles. Fluorescent fixture lens frames on recessed and surface mounted troffers shall be one assembly with mitered corners. Parabolic louvers shall have a low iridescent finish and 45 degree cut-off. Louver intersection joints shall be hairline type and shall conceal mounting tabs or other assembly methods. Louvers shall be free from blemishes, lines or defects which distort the visual surface. Integral ballast and wireway compartments shall be easily accessible without the use of special tools. Housings shall be constructed to include grounding necessary to start the lamps. Open fixtures shall be equipped with a sleeve, wire guard, or other positive means to prevent lamps from falling. Medium bi-pin lampholders shall be twist-in type with positive locking position. Long compact fluorescent fixtures and fixtures utilizing U-bend lamps shall have clamps or secondary lampholders to support the free ends of the lamps.

c. High intensity discharge fixture shall comply with UL 1572. Recessed ceiling fixtures shall comply with NEMA LE 4. Reflectors shall be anodized aluminum. Fixtures for horizontal lamps shall have position oriented lampholders. Lampholders shall be pulse-rated to 5,000 volts. Fixtures indicated as classified or rated for hazardous locations or special service shall be designed and independently tested for the environment in which they are installed. Recessed lens fixtures shall have extruded aluminum lens frames. Ballasts shall be integral to fixtures and shall be accessible without the use of special tools. Remote ballasts shall be encased and potted. Lamps shall be shielded from direct view with a UV absorbing material such as tempered glass, and shall be circuited through a cut-off switch which will shut off the lamp circuit if the lens is not in place.

e. Exit Signs

Exit signs shall be ENERGY STAR compliant, thereby meeting the following requirements. Input power shall be less than 5 watts per face. Letter size and spacing shall adhere to NFPA 101. Luminance contrast shall be greater than 0.8. Average luminance shall be greater than 15 cd/m^2 measured at normal (0 degree) and 45 degree viewing angles. Minimum luminance shall be greater than 8.6 cd/m^2 measured at normal and 45 degree viewing angles. Maximum to minimum luminance shall be less than 20:1 measured at normal and 45 degree viewing angles. The manufacturer warranty for defective parts shall be at least 5 years.

2.12.4 Lampholders, Starters, and Starter Holders

UL 542

2.12.5 Ultrasonic, and Passive Infrared Occupancy Sensors

UL 916

2.13 LOW-VOLTAGE FUSES AND FUSEHOLDERS

2.13.1 Fuses, Low Voltage Cartridge Type

NEMA FU 1.

2.13.2 Fuses, High-Interrupting-Capacity, Current-Limiting Type

Fuses, Class G, J, L and CC shall be in accordance with UL 198C.

2.13.3 Fuses, Class K, High-Interrupting-Capacity Type

UL 198D.

2.13.4 Fuses, Class H

UL 198B.

2.13.5 Fuses, Class R

UL 198E.

2.13.6 Fuses, Class T

UL 198H.

2.13.7 Fuses for Supplementary Overcurrent Protection

UL 198G.

2.13.8 Fuses, D-C for Industrial Use

UL 198L.

2.13.9 Fuseholders

UL 512.

2.14 INSTRUMENTS, ELECTRICAL INDICATING

ANSI C39.1.

2.15 MOTOR CONTROLS AND MOTOR CONTROL CENTERS

2.15.1   General

NEMA ICS 1, NEMA ICS 2, NEMA ICS 3 and NEMA ICS 6, and UL 508 and UL 845. Panelboards supplying non-linear loads shall have neutrals sized for 200 percent of rated current.

2.15.2   Motor Starters

Combination starters shall be provided with circuit breakers.

2.15.3   Thermal-Overload Protection

Each motor of 93 W   or larger shall be provided with thermal-overload protection. Polyphase motors shall have overload protection in each ungrounded conductor. The overload-protection device shall be provided either integral with the motor or controller, or shall be mounted in a separate enclosure. Unless otherwise specified, the protective device shall be of the manually reset type. Single or double pole tumbler switches specifically designed for alternating-current operation only may be used as manual controllers for single-phase motors having a current rating not in excess of 80 percent of the switch rating.

2.15.4   Low-Voltage Motor Overload Relays

2.15.4.1   General

Thermaloverload relays shall conform to NEMA ICS 2 and UL 508. Overload protection shall be provided either integral with the motor or motor controller, and shall be rated in accordance with the requirements of NFPA 70. Standard units shall be used for motor starting times up to 7 seconds.

2.15.4.2   Construction

Manual reset type thermal relay shall be melting alloy construction. Automatic reset type thermal relays shall be bimetallic construction. Magnetic current relays shall consist of a contact mechanism and a dash pot mounted on a common frame.

2.15.4.3   Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Trip current ratings shall be established by selection of the replaceable overload device and shall not be adjustable. Where the controller is remotely-located or difficult to reach, an automatic reset, non-compensated overload relay shall be provided. Manual reset overload relays shall be provided otherwise, and at all locations where automatic starting is provided. Where the motor is located in a constant ambient temperature, and the thermal device is located in an ambient temperature that regularly varies by more than minus 10 degrees C, an ambient temperature-compensated overload relay shall be provided.

2.15.5   Automatic Control Devices

2.15.5.1   Direct Control

Automatic control devices (such as thermostats, float or pressure switches) which control the starting and stopping of motors directly shall be designed for that purpose and have an adequate kilowatt rating.

2.15.5.2 Pilot-Relay Control

Where the automatic-control device does not have such a rating, a magnetic starter shall be used, with the automatic-control device actuating the pilot-control circuit.

2.15.5.3 Manual/Automatic Selection

a. Where combination manual and automatic control is specified and the automatic-control device operates the motor directly, a double-throw, three-position tumbler or rotary switch (marked MANUAL-OFF-AUTOMATIC) shall be provided for the manual control.

b. Where combination manual and automatic control is specified and the automatic-control device actuates the pilot control circuit of a magnetic starter, the magnetic starter shall be provided with a three-position selector switch marked MANUAL-OFF-AUTOMATIC.

c. Connections to the selector switch shall be such that; only the normal automatic regulatory control devices will be bypassed when the switch is in the Manual position; all safety control devices, such as low-or high-pressure cutouts, high-temperature cutouts, and motor-overload protective devices, shall be connected in the motor-control circuit in both the Manual and the Automatic positions of the selector switch. Control circuit connections to any MANUAL-OFF-AUTOMATIC switch or to more than one automatic regulatory control device shall be made in accordance with wiring diagram approved by the Contracting Officer unless such diagram is included on the drawings. All controls shall be 120 volts or less unless otherwise indicated.

2.15.6 Motor Control Centers

Control centers shall conform to the requirements of NEMA ICS 1, NEMA ICS 2, NEMA ICS 3 and NEMA ICS 6, and UL 508 and UL 845. Control centers shall be indoor type and shall contain combination starters and other equipment as indicated. Control centers shall be NEMA ICS 2, Class I, Type B. Each control center shall be mounted on floor sills or mounting channels. Each circuit shall have a suitable metal or laminated plastic nameplate with white cut letters. Motor control centers shall be provided with a full-length ground bus bar.

2.16 PANELBOARDS

Dead-front construction, NEMA PB 1 and UL 67, door-in-door hinged panel, copper bussing.

2.17 RECEPTACLES

2.17.1 Heavy Duty Grade

NEMA WD 1. Devices shall conform to all requirements for heavy duty receptacles.

2.17.2 Standard Grade

UL 498.

2.17.3 Ground Fault Interrupters

UL 943, Class A or B.

2.17.4 Hazardous (Classified) Locations

UL 1010.

2.17.5 NEMA Standard Receptacle Configurations

NEMA WD 6.

a. Single and Duplex, 15-Ampere and 20-Ampere, 125 Volt

15-ampere, non-locking: NEMA type 5-15R, locking: NEMA type L5-15R,
20-ampere, non-locking: NEMA type 5-20R, locking: NEMA type L5-20R.

b. 15-Ampere, 250 Volt

Two-pole, 3-wire grounding, non-locking: NEMA type 6-15R, locking: NEMA type L6-15R. Three-pole, 4-wire grounding, non-locking: NEMA type 15-15R, locking: NEMA type L15-15R.

c. 20-Ampere, 250 Volt

Two-pole, 3-wire grounding, non-locking: NEMA type 6-20R, locking: NEMA type L6-20R. Three-pole, 4-wire grounding, non-locking: NEMA type 15-20R, locking: NEMA type L15-20R.

d. 30-Ampere, 125/250 Volt

Three-pole, 3-wire, non-locking: NEMA type 10-30R, locking: NEMA type L10-30R. Three-pole, 4-wire grounding, non-locking: NEMA type 14-30R, locking: NEMA type L14-30R.

e. 30-Ampere, 250 Volt

Two-pole, 3-wire grounding, non-locking: NEMA type 6-30R, locking: NEMA type L6-30R. Three-pole, 4-wire grounding, non-locking: NEMA type 15-30R, locking: NEMA type L15-30R.

f. 50-Ampere, 125/250 Volt

Three-pole, 3-wire: NEMA type 10-50R. Three-pole, 4-wire grounding: NEMA type 14-50R.

g. 50-Ampere, 250 Volt

Two-pole, 3-wire grounding: NEMA type 6-50R. Three-pole, 4-wire grounding: NEMA type 15-50R.

2.18 SPLICE, CONDUCTOR

UL 486C.

2.19 SNAP SWITCHES

UL 20.

2.20 TAPES

2.20.1 Plastic Tape

UL 510.

2.20.2 Rubber Tape

UL 510.

2.21 TRANSFORMERS

Single- and three-phase transformers shall have two windings per phase. Full-capacity standard NEMA taps shall be provided in the primary windings of transformers unless otherwise indicated. Three-phase transformers shall be configured with delta-wye windings, except as indicated. All transformers shall be UL listed as suitable for supplying such loads with a total K-factor not to exceed K-13 and have neutrals sized for 200 percent of rated current.

2.26.1 Transformers, Dry-Type

Transformers shall have 220 degrees C insulation system for transformers 15 kVA and greater, and shall have 180 degrees C insulation system for transformers rated 10 kVA and less, with temperature rise not exceeding 80 degrees C under full-rated load in maximum ambient temperature of 40 degrees C. Transformer of 80 degrees C temperature rise shall be capable of carrying continuously 130 percent of nameplate kVA without exceeding insulation rating.

a. 600 Volt or Less Primary:

NEMA ST 20, UL 506, general purpose, dry-type, self-cooled, ventilated. Transformers shall be provided in NEMA 1 enclosure. Transformers shall be quiet type with maximum sound level at least 3 decibels less than NEMA standard level for transformer ratings indicated.

2.26.3 Average Sound Level

The average sound level in decibels (dB) of transformers shall not exceed the following dB level at 300 mm for the applicable kVA rating range listed unless otherwise indicated:

kVA Range	dB Sound Level
1-50	50
51-150	55
151-300	58
301-500	60
501-700	62
701-1000	64
1001-1500	65
1501 & above	70

2.22 480-VOLT STATION SERVICE SWITCHGEAR

2.22.1 General

Except as otherwise specified or indicated , the design, construction and tests of the switchgear shall conform to the applicable requirements of NEMA SG 5, IEEE C37.13, and IEEE C37.20.1. The switchgear will be used to distribute power from one 3000/3360 kVA, 12470-480 volt, 3-phase, 60-Hz, station service transformers to 480-volt power distribution centers and to other station service loads. The switchgear assembly shall contain two main bus sections connected by a bus tie circuit breaker. Each main bus section will be connected to a supply transformer through a main supply circuit breaker. The two main supply circuit breakers and the bus tie circuit breaker shall be electrically operated and will normally be remotely controlled. Automatic bus transfer shall be provided as specified in paragraph Automatic Bus Transfer. The switchgear shall have instruments, control accessories, and other equipment mounted on the front panels and inside the switchgear as shown and as specified. The annunciator window group will be furnished by the Government for mounting and wiring by the Contractor.

2.22.2 Enclosure and Framework

2.22.2.1 Switchgear

The switchgear shall be of the totally-enclosed, free-standing, dead-front type built on a suitable framework of structural steel, or by an equivalent approved method, which shall provide a self-supporting and stable structure. Metal-enclosed switchgear construction consisting of ribbed side sheets and fabricated framework which is functionally equivalent to the structural steel framework specified will be acceptable. The framework and structure shall be sufficiently rigid to withstand operation of the equipment or any stresses due to short circuits. Each shipping assembly shall also be sufficiently rigid, with the addition of temporary members if required, to withstand handling during shipment and installation.

2.22.2.2 Enclosure

The enclosure shall be made of selected smooth sheet steel panels, suitably supported. Doors and panels used to support instruments and other devices and barriers between compartments shall not be less than No. 11 MSG. Exposed panels on the front and ends of the enclosure shall be bent angle or channel edges with all corner seams welded and ground smooth, or shall be the manufacturer's equivalent construction as approved. The front outside surfaces shall not be drilled or welded for the purpose of attaching wires or mounting devices if such holes or fastenings will be visible from the front.

2.22.2.3 Drawout Circuit Breaker (Main and Tie)

Each drawout type circuit breaker shall be completely enclosed in a metal compartment. Access to the circuit breakers shall be provided through hinged steel doors. Access to instrument and relay wiring, instrument transformers and fuses, shall also be through hinged doors. All hinged doors shall have bent angle or channel edges, invisible hinges and suitable latches or fastenings. Access to bus compartments shall be through removable bolted panels, cover plates or hinged doors.

2.22.2.4 Ventilating Opening

Ventilating openings shall be provided as required and shall preferably be of the grille type. All ventilating openings shall be provided with corrosion-resistant insect-proof screens on the inside.

2.22.2.5 Foundations

Continuous channel iron foundations, complete with bolts and drilled holes for grouting and anchoring to the floor, shall be furnished by the Contractor for the complete length (front and rear) of each switchgear assembly. Channel construction and drilling shall be as required for mounting the equipment. The channels shall be designed for flat mounting and maximum channel depth shall be 63 mm. The foundation channels shall be placed on top of the floor, fastened in place, and then filled with grout. Additional channel or substantial metal trim shall be provided flush with the end panels to completely enclose the bases across the ends of the equipment assemblies where exposed to view.

2.22.3 Buses and Connections

a. The buses in each main bus section shall have a continuous current-carrying capacity of not less than 4,000 amperes without exceeding the temperature limits specified in IEEE C37.20.1. The buses shall have mechanical and thermal capacities coordinated with the interrupting rating of the power supply circuit breakers. Bus bars shall be of hard-drawn copper. Shop splices and tap connections shall be brazed, pressure-welded or bolted. All splices for field assembly shall be bolted. Where bolted connections are used, contact surfaces shall be silver-plated and shall be equipped with provisions for adequate clamping. The buses shall be mounted on insulating supports of wet process porcelain, glass polyester, or suitable molded material. All primary connections including the power connections to the line side of the circuit breakers shall be by bus bar.

b. The standard phasing within equipment housing for AC power circuits shall be A-B-C from left to right when facing the front of the equipment, A-B-C from top to bottom, and A-B-C from front to back. Nonstandard phasing in any compartment will be permitted only upon approval and providing each phase is identified and a warning sign, "Nonstandard Phasing," is incorporated within such a compartment

c. Blank compartments without buses and small spare compartments with buses and complete provisions for installing future feeder circuit breakers shall be provided where shown

2.22.4 Power Circuit Breakers

2.22.4.1 General

The power supply, bus tie, air circuit breakers shall be 3-pole, dead-front, drawout type rated 600 volts AC, conforming to the requirements of NEMA SG 3; IEEE C37.13; ANSI C37.16; and NEMA C37.17. All circuit breakers of the same frame size and type of operation (electrical or manual) shall be interchangeable. Suitable means shall be provided for removing and handling the drawout circuit breakers. These means may include support from the top of the switchgear enclosure without interference with incoming or outgoing wiring. The Government reserves the right to change the indicated current ratings, within frame limits, of the tripping devices at the time the shop drawings are submitted for approval. Overcurrent trip alarm contacts, with means for manual reset, shall be furnished as indicated . Covers shall be provided over readily accessible energized portions to prevent hazards to personnel when withdrawing or inserting the breakers.

2.22.4.2 Power Supply and Bus Tie Circuit Breakers

The 2 power supply circuit breakers and the bus tie circuit breaker shall be electrically-operated drawout type with the closing mechanism designed for operation on 125 volts DC. The circuit breakers shall be rated 600 volts AC, 4000 ampere frame size, 100,000 amperes symmetrical interrupting capacity at 600 volts AC, with continuous current ratings as indicated. Each circuit breaker shall be provided with functional components in accordance with Table 1 of IEEE C37.13, including means for manual emergency tripping and manual closing for maintenance operation. Each power supply breaker and the bus tie circuit breaker shall be provided with a solid-state direct-acting over-current tripping device consisting of long-time-delay, short-time-delay, and ground fault elements. The bus tie circuit breaker shall be furnished without an overcurrent trip device but shall be provided with a 125-volt DC shunt trip device. Long-time and short-time-delay operation bands shall be selected to provide maximum selectivity between the primary supply protective relays, power supply breakers, bus tie breaker, feeder breakers and motor control center molded case breakers for a fault on a feeder circuit. Information on primary relays and molded case breakers will be supplied to the Contractor by the Government. The 2 power supply circuit breakers and the bus tie circuit breaker shall be electrically interlocked so that only 2 of the 3 breakers can be in the closed position at the same time. A local test control switch shall be provided for each electrically-operated circuit breaker which shall be electrically interlocked through cell switches or secondary disconnects to prevent breaker operation except when the breaker is in the test position. Sufficient breaker auxiliary switch contacts and cell switches shall be provided to accomplish the required breaker control and interlocking system as shown. At least 4 auxiliary switch contacts shall be provided on each breaker. At least 2 spare auxiliary switch contacts, one normally-open and one normally-closed, shall also be provided on each electrically-operated breaker.

2.22.4.3 Feeder Insulated Case Circuit Breakers

Feeder breakers shall be independent manually-operated type with manually-charged stored energy closing mechanism and with frame sizes as indicated , and shall be rated 600 volts AC. Circuit breakers with 600-ampere frames shall have a short-circuit interrupting capacity of not less than 100,000 rms symmetrical amperes at 600 volts AC. Each feeder breaker, except as specified otherwise, shall be provided with a solid-state direct-acting overcurrent tripping device consisting of a long-time-delay element, a short-time-delay, and ground fault element. The long-time-delay trip elements for direct-acting overcurrent tripping devices shall be adjustable over an approximate range of 80 to 110 percent of the trip ampere rating. The short-time-delay trip elements, for the direct-acting overcurrent tripping devices shall be adjustable over a range of approximately 4 to 10 times the ampere rating. Manually-operated drawout type circuit breakers shall be fitted with suitable operating handles, preferably of the pistol grip type, or vertical lever type, designed to close the breaker with a rotary motion of less than 180 degrees. All breakers shall be designed for tripping by a rotary motion in the opposite direction or by pressing a readily accessible trip button. The operating handles shall be easily removable when it is necessary to open the compartment door and easily replaceable for operating the breaker in the withdrawn or test position. Each breaker shall be equipped with a conspicuous mechanical target visible with the breaker in the normal operating position to indicate whether the breaker is open or closed and shall be provided with a manually-reset bell alarm contact to energize the annunciator circuit only when the breaker is automatically tripped on a fault or overload. The circuit breaker for the powerhouse crane feeder shall be manually-operated type equipped with a 125-volt DC shunt trip attachment for emergency operation from remote stations.

2.22.4.4 Automatic Bus Transfer

The stations shall be provided with automatic bus transfer. The automatic transfer arrangement shall be as shown by the schematic diagrams and shall incorporate the following (normal operation will be with both supply breakers closed and the bus tie breaker open):

a. Loss of voltage on one bus shall cause the associated supply breaker to trip and the bus tie breaker to close.

b. Automatic transfer control will cease to function if either of the supply breakers or the bus tie breaker trip on overcurrent.

c. Recovery of voltage from 1 of the 2 normal sources shall (after a time delay) open the bus tie breaker and close the associated supply breaker

d. Recovery of voltage from both normal sources shall (after a time delay) open the bus tie breaker and close the supply breakers.

e. After pickup by the voltage relays, the bus transfer operation shall be accomplished within approximately 1 second

2.22.4.5 TITLE NEEDE

Power supply circuit breakers shall be interlocked with "temporary" generator circuit breaker via key interlock.

Upon closing of "temporary" generator, both power supply circuit breakers shall close.

2.27.4 Wiring

2.27.4.1 Control Panel and Power Wiring

Control panel wiring shall be stranded copper switchboard wire with 600-volt insulation. The wire shall be Type SIS as listed in NFPA 70 and shall meet the requirements of NEMA WC 7. Hinge wire shall have class K stranding. Current transformer secondary leads shall be not smaller than No. 10 AWG. The minimum size of wire for all other control wiring shall be No. 14 AWG. Power wiring for 480-volt circuits and below shall be of the same type as control panel wiring and the minimum size shall be No. 12 AWG.

2.27.4.2 Terminals and Installation

a. Control wiring within the assembly housings shall be furnished and installed by the Contractor as specified. All control wiring leaving equipment shall be run to and terminated on terminal blocks. Terminal blocks and internal wiring shall be provided for connection of remote circuits to all spare auxiliary and alarm contacts, remote annunciators, remote control switches, and pilot devices and remote indicating lights where such devices are specified and applicable to the equipment involved. Each individual potential transformer lead shall be brought out to a terminal block. Potential transformers for ground detecting circuits shall be grounded at the equipment. Potential transformers for metering circuits will be remotely grounded by the Government. There shall be no splices in the wiring and all connections shall be made at terminal studs or blocks. Terminal blocks shall be added for wiring to devices having leads instead of terminals. Indented terminals, Burndy Type YAV10 or an approved equal, shall be used on all wires terminated on screw or stud terminals. All screw terminals shall have toothed lock washers and all stud terminals shall have contact nuts and either locking nuts or lock washers.

b. All external control cables and power cables will enter the switchgear in conduit. Space for cables as shown shall be provided. The 600-volt metal-enclosed buses shall enter the switchgear from above. Matching openings shall be provided in the switchgear to permit the entrance of the bus into the switchgear through the concrete openings. Clam-style terminals of sizes indicated shall be provided for all main power cable leaving the switchgear. The terminals shall be of the heavy-duty, full clamp type, Burndy "Qiklug", or approved equal. Adequate provisions shall be included for supporting the Government's cables between the conductor terminating points and where they enter or leave the switchgear.

2.27.4.3 Terminal Blocks

a. Terminal blocks for control wiring shall be molded or fabricated type with barriers, rated not less than 600 volts, type B. The terminals shall be removable binding, fillister or washer head screw type, or stud type with contact and locking nuts. The terminals shall be not less than No. 10 in size and shall have sufficient length and space for connecting at least 2 indented terminal connectors for No. 19/22 AWG conductors to each terminal. The terminal arrangement shall be subject to approval. Not less than 10 percent, but in no case less than 2, spare terminals shall be provided on each block or group of blocks.

b. Short-circuiting type terminal blocks shall be furnished for all current transformer secondary leads and shall have provision for shorting together all leads from each current transformer without first opening any circuit. These terminal blocks shall be made by the same manufacturer as the terminal blocks for control wiring listed above, type B.

c. White or other light-colored plastic marking strips, fastened by screws to each terminal block, shall be provided for control wire designations. The manufacturer's wire number and the Government's wire number shall both be shown for each connected terminal on the marking strips with permanent marking fluid. The marking strips shall be reversible to permit marking both sides, or two marking strips shall be furnished with each block, to accommodate the two sets of wire numbers.

d. Load terminal blocks rated not less than 600 volts and of adequate capacity shall be provided for the conductors of power circuits except those supplied from air circuit breakers. The terminals shall be of either the stud type with contact nuts and locking nuts or of the removable screw type, having length and space for at least two indented terminal connectors of the size required on the conductors to be terminated. For conductors rated more than 50 amperes all screws shall have hexagonal heads. For conductors rated 50 to 99 amperes the minimum screw size shall be 8 mm. Conducting parts between connected terminals shall have adequate contact surface and cross section to operate without overheating. Each connected terminal shall have the circuit designation or wire number marked on or near the terminal in permanent contrasting color.

e. Special attention shall be given to wiring the terminal arrangement on the terminal blocks to permit the individual conductors of each external Government-furnished cable to be terminated on adjacent terminal points. The wire (terminal point) designations used on the Contractor's wiring diagrams and printed on terminal block marking strips may be according to the Contractor's standard practice; however, additional wire and cable designations for identification of remote (external) circuits may be required.

2.27.5 Grounding

The switchgear assembly shall include a full-length interior ground bus of copper to which the housing, framework, cable supports, bus supports, and non-current carrying metallic parts of all equipment and conduits shall be grounded insofar as practicable. No soldered connections shall be used in the ground leads. If the operating mechanism of drawout units is not permanently grounded, ground contacts shall be provided to automatically connect the movable element to the ground buses. These connections shall make before the main disconnecting devices upon insertion, and break after the main disconnecting devices upon withdrawal. Grounding shall conform toIEEE C37.20.1 except that the ground bus shall have a continuous current-carrying capacity not less than 25 percent of the continuous rating of the power supply circuit breakers.

2.27.7 Instrument Transformers

2.27.7.1 Voltage Transformers

Five 480-120 volt, 200 volt-ampere capacity, voltage transformers shall be provided for each main 480-volt bus section. Two of the transformers shall be used for metering and 3 of the transformers shall be used with the ground detection equipment. Voltage transformers shall conform to IEEE C57.13 and shall have an ANSI accuracy classification of 0.3W, 0.3X, and 1.2Y or better. The full-wave impulse level shall be not less than 10 kV. Each voltage transformer shall be protected with removable primary and secondary fuses. Fuses shall be installed in each ungrounded lead and located adjacent to the transformers in an easily accessible place.

2.27.7.2 Current Transformers

Dry type current transformers as shown shall be furnished, installed and wired to the specified terminal blocks. These current transformers shall conform to IEEE C57.13, and shall have the ratios indicated . The current transformers shall be rated not less than 600 volts AC, 10 kV BIL, and the

ANSI accuracy classification shall be in accordance with IEEE C37.20.1 or better. If cable connections to the transformer primary are required, terminals of an approved solderless type and proper size shall be furnished. If transformers are connected to buses, proper connections shall be furnished, complete with bolts, nuts, washers and other accessories.

2.27.8   Ground Detection Equipment

Ground detection equipment shall be furnished for each bus section of the switchgear, to be used for indication and annunciation of grounds of the 480-volt system. The equipment shall consist of 3 instrument voltage transformers complete with primary and secondary fuses, connected wye-delta, with neutral of primary wye grounded and with the coil of a voltage ground detector relay connected in the broken delta corner of the secondary windings of the 3 voltage transformers in accordance with IEEE C37.20.1. Two ground detector relays shall be provided, one for each bus section of the switchgear.

2.27.9   Relays

2.27.9.1   General

a. Relays shall conform to the applicable requirements of IEEE C37.90. The relays shall be back-connected, semi-flush-mounted, switchboard type with black, rectangular, dust-tight cases, removable covers with windows, and means of sealing against tampering. Relays, except auxiliary relays, shall be drawout type with built-in test facilities arranged so that the relays can be tested in position or withdrawn from the fronts of the cases without opening current transformer secondary circuits, disturbing external circuits, or requiring disconnection of leads from the relay terminals. The test devices shall permit testing with energy from either the instrument transformers or an external power supply.

b. Protective relays shall be provided with all required auxiliaries, including auxiliary instrument transformers and reactors, to adjust currents, potentials and phase angles for proper operation. External relay auxiliaries shall be mounted in compact assemblies back of the panels and adjacent to the relays. AC relays shall be suitable for use on 60-Hz circuits and for operation with the instrument transformer ratings and connections shown . Relay current coils shall be able to withstand 35 times normal current for 1/2 second, and relay voltage coils shall be able to withstand 110 percent rated voltage continuously without damage. Time delay features shall not depend upon oil dashpots or other devices which are appreciably affected by temperature. Each relay shall be provided with 1 or more operation indicators and/or indicating Contractor switches with targets and external target reset devices, and the circuits shall be arranged for positive target operation. Seal-in Contractor and suitable loading resistors shall be provided where required. Separate relay operating function, such as instantaneous trip attachments and different zones for distance relays, shall have separate targets and contacts.

c. Relay contacts shall be silver-to-silver, electrically independent, chatterproof and non-bouncing, and suitable for use on 125-volt ungrounded DC circuits unless otherwise specified or shown . Where more than 1 electrically-independent relay contact is required, as indicated , and it is not feasible to provide more than 1 such contact, or if 2 contacts are available but are not electrically independent, auxiliary relays shall be furnished to provide the required additional contacts.

2.27.9.2 AC Voltage Relays

Voltage relays other than ground detector relays shall be induction-disc inverse-time type with adjustable time and voltage settings and with semiflush mounting, drawout case type B. Ground detector relays shall be induction-disc inverse-time overvoltage type rated 199 volts AC with low pickup, semiflush mounting in drawout case with circuit closing contacts suitable for 125-volt DC ungrounded circuits. They shall be from the same manufacturer as the AC voltage relays, type B.

2.27.9.3 Auxiliary relays

Auxiliary relays for bus transfer control shall be semiflush back-connected type for front-of-panel mounting. The semiflush cases shall be black and shall match in appearance other relay cases on the switchgear. Auxiliary relays for interior mounting shall be provided with covers. Relay coils and contacts shall be suitable for continuous operation at 125 volts DC, shall be furnished with resistors where required, and shall be of a type to require a minimum continuous current. The auxiliary relays shall be high-speed, multi-contact, self-reset type, from the same manufacturer as the AC voltage relays, type B.

2.27.10 Control and Instrument Switches

2.27.10.1 General

All control switches shall be of the rotary switchboard type with handles on the front and the operating contact mechanisms on the rear of the panels, type B. Each switch shall be provided with ample contact stages to perform the functions of the control system. Contacts shall be self-aligning and shall operate with a wiping action. A positive means of maintaining high pressure on closed contacts shall be provided. Compression springs or pivotal joints shall not carry current. The covers or plates on the switches shall be readily removable for inspection of contacts. All control switches shall be suitable for operation on 600-volt AC or 250-volt DC circuits. All such switches shall be capable of satisfactorily withstanding a life test of at least 10,000 operations with rated current flowing in the switch contacts. The switches shall be capable of continuously carrying 20 amperes without exceeding a temperature rise of 30 degrees C. The single-break inductive load interrupting rating of switches shall be not less than 1.5 amperes for 125 volts DC or 10 amperes for 115 volts AC.

2.27.10.2 Escutcheons and Nameplates

Each control switch shall be provided with an escutcheon clearly marked to show each operating position. The switch identifications shall be engraved on the escutcheon plates or on separate nameplates. The escutcheon and nameplate markings shall be subject to approval.

2.27.10.3 Switch Features

a. Control and instrument switches shall be suitable for the intended use and shall have the features shown on the schematic diagrams and switch development drawings. The switches shall have modern handles or keys of pistol grip, oval, round notched or knurled type, and shall be black color unless otherwise specified.

b. Control switches for electrically-operated circuit breakers shall be 3 position momentary-contact type with spring return to neutral position, and shall have modern-black, heavy duty pistol grip handles. Circuit breaker control switches shall have mechanical operation indicators to show the last manual operation of the switches, and shall have slip contacts when so indicated or required.

c. Instrument and meter transfer switches and selector switches shall be the maintained-contact type with the required number of positions, and shall have round notched or knurled handles. Ammeter switches shall not open the secondary circuits of current transformers at any time. Instrument switches for potential selection shall have oval handles.

2.27.11 Indicating Lamp Assemblies

Indicating lamp assemblies shall be of the switchboard type, insulated for 125-volt DC service, with appropriately colored caps and integrally mounted resistors for nominal 125-volt DC service (140 volts maximum). Lamps shall be long-life low-wattage type replaceable from the front of the panels and any special tools required for lamp replacement shall be furnished. Color caps shall be made of transparent or translucent material which will not be softened by the heat from the lamps. Insofar as practicable, all color caps shall be similar and interchangeable, and all lamps shall be of the same type and rating.

2.27.12 Indicating Instruments

2.27.12.1 General

Electrical indicating instruments shall conform to the applicable requirements of ANSI C39.1 and the accuracy rating shall be within 1 percent of full-scale value. The instruments shall be back-connected semiflush mounting. Instruments shall have white dials, circular scales, black scale markings, and black tapered antiparallax pointers. Instrument cases shall be dust tight with shadowproof covers and anti-glare windows. Taut-band suspension shall be provided where this design is available. Zero adjustments accessible from the front without removal of covers shall be provided for instruments with spring control. AC instruments shall be designed and calibrated for use on 60-Hz circuits and for operation from 120-volt secondaries of voltage transformers and 5-ampere secondaries of current transformers, as shown. AC instrument potential coils shall be designed for continuous operation at 150-volts, and AC instrument current coils shall be capable of withstanding 40 times rated current for two seconds. Instrument identification legends shall be neatly printed on the dials or on separate legend plates inside the cases. Instrument scales shall be as specified, or as approved if scales are not specified, and appropriate for the application.

2.27.12.2 Rectangular Switchboard Instruments

Instruments shall be 108 mm minimum rectangular type with nominal 250-degree scale angle and zero-left scales

2.27.12.3   AC Voltmeters

AC voltmeters shall be provided with expanded type scales

2.27.13   Nameplates

Each item of equipment mounted on the switchgear which does not have a suitable designation included as an integral part of the device shall be provided with an engraved nameplate or with other approved suitable means of identification. Nameplates shall be made of laminated sheet plastic or of anodized aluminum approximately 3 mm thick, engraved to provide white letters on a black background. Equipment of the withdrawal type shall be provided with nameplates mounted on the removable equipment in locations visible when the equipment is in place. The nameplates shall be fastened to the panels in proper positions with black finished roundhead screws.

2.23   SWITCHBOARDS

The switchboards shall be dead-front switchboards conforming to NEMA PB 2 and labeled under UL891. The switchboards shall be completely enclosed self-supporting metal structures with the required number of vertical panel sections, buses, molded-case circuit breakers, and other devices as show on the drawings. Switchboards shall be fully rated for a short circuit current of 100,000 symmetrical amperes RMS AC.

2.23.1   Enclosure

Each switchboard enclosure shall be NEMA type 2, built with selected smooth sheet steel panels of not less than 1.9 millimeters (No. 14 gauge). Exposed panels on the front and ends shall have bent angle or channel edges with all corner seams welded and ground smooth. The front outside surfaces shall not be drilled or welded for the purpose of attaching wires or mounting devices if such holes or fastenings will be visible from the front. The front panels shall be made in sections flanged on four sides and attached to the framework by screws and arranged for ready removal for inspection or maintenance. Ventilating openings shall be provided as required and shall preferably be of the grille type. All ventilating openings shall be provided with corrosion-resistant insect-proof screens on the inside. Each switchboard shall be provided with a channel iron base at front, rear, and sides, with exposed ends covered by welded steel plates. Grout holes shall be provided. The switchboard sections shall be bolted to the base. Switchboards shall be mounted as shown on the drawings and mounting materials shall be furnished by the Contractor as indicated. All interior and exterior steel parts shall be treated to inhibit corrosion and shall be painted as specified in paragraph PAINTING.

2.23.2   Bus

All buses shall be of copper and all bolted splices and connections between buses and for extensions or taps for equipment shall be tin or silver plated throughout. Copper bars and shapes for bus conductors shall conform to the applicable requirements of ASTM B 187. All splices for field assembly shall be bolted with at least two bolts and shall employ the use of "Belleville" washers in the connection. Horizontal and vertical power buses have minimum current ratings as shown on the drawings. The buses shall be insulated for not less than 600 volts. Shop splices and tap connections shall be brazed, pressure welded or bolted. All splices for field assembly sjall be bolted. The buses shall be mounted on insulating supports of wet process porcelain, glass polyester, or suitable molded material, and shall be braced to withstand not less than 100,000 symmetrical amperes ac.

2.23.3   Grounding Bus

A copper ground bus, rated not less than 300 amps, extending the entire length of the assembled structure, shall be mounted near the bottom of enclosure. A full clamp type solderless copper or copper alloy lug for No. 2/0 AWG stranded copper cable shall be provided at each end of the bus for connection to the station grounding system.

2.23.4   Components

Each switchboard shall be equipped

2.23.5   Molded Case Ciruit Breakers

Molded case circuit breakers shall conform to the applicable requirements of NEMA AB 1 and NEMA AB 3, shall be fully rated, and shall have voltage ratings and interrupting rating stated. For circuit breakers of the same ampere frame size, 3 pole and 2 pole circuit breakers shall be the same width at 3 single pole and 2 single pole circuit brekers respectively. The circuit breakers shall be manually-operated and shall have trip-freee operating mechanisms of the quick-make, quick-break type. All poles of each breaker shall be operated simultaneously by means of a common handle, and shall be enclosed in a common molded plastic case. The contacts of multi-pole breakers shall open simultaneously when the breaker is tripped manually or automatically. The operating handles shall clearly indicate whether the breakers are in "On", "Off", or "Tripped" position. The circuit breakers shall be of the individually-mounted, stationary type, shall all be products of the same manufacturer, and shall be interchangeable when of the same frame size. Each circuit breaker shall be provided with mechanical pressure type terminal lugs for single-conductor stranded copper cables of the size required by the specifications or shown.

2.23.6   Trip Units

The circuit breakers shall be of the automatic type provided with combination thermal and instantaneous magnetic trip units. Instantaneous magnetic trip units shall be set at approximately 10 times the continuous current ratings of the circuit breakers.

2.23.7   480-Volt AC Circuits

Circuit breakers for 480-volt AC circuits shall be rated 600 volts AC, and shall have a minimum NEMA interrupting capacity of 14,000 symmetrical amperes at 600 volts AC.

2.22.8   120-Volt and 208-Volt AC Circuits

Circuit breakers for 120-volt and 208-volt AC circuits shall be rated not less than 250 volts DC, and either 120/240 or 240 volts AC, and shall have a minimum NEMA interrupting capacity of 10,000 symmetrical amperes.

PART 3   EXECUTION

3.1 GROUNDING

Grounding shall be in conformance with NFPA 70, the contract drawings, and the following specifications.

3.1.1 Ground Rods

The resistance to ground shall be measured using the fall-of-potential method described in IEEE Std 81. The maximum resistance of a driven ground shall not exceed 25 ohms under normally dry conditions. If this resistance cannot be obtained with a single rod, additional rods not less than 1.8 meters on centers, or if sectional type rods are used, additional sections may be coupled and driven with the first rod. In high-ground-resistance, UL listed chemically charged ground rods may be used. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, the Contracting Officer shall be notified immediately. Connections below grade shall be fusion welded. Connections above grade shall be fusion welded or shall use UL 467 approved connectors.

3.1.2 Ground Bus

Ground bus shall be provided in the electrical equipment rooms as indicated. Noncurrent-carrying metal parts of transformer neutrals and other electrical equipment shall be effectively grounded by bonding to the ground bus. The ground bus shall be bonded to both the entrance ground, and to a ground rod or rods as specified above having the upper ends terminating approximately 100 mm above the floor. Connections and splices shall be of the brazed, welded, bolted, or pressure-connector type, except that pressure connectors or bolted connections shall be used for connections to removable equipment. For raised floor equipment rooms in computer and data processing centers, a minimum of 4, one at each corner, multiple grounding systems shall be furnished. Connections shall be bolted type in lieu of thermoweld, so they can be changed as required by additions and/or alterations.

3.1.3 Grounding Conductors

A green equipment grounding conductor, sized in accordance with NFPA 70 shall be provided, regardless of the type of conduit. Equipment grounding bars shall be provided in all panelboards. The equipment grounding conductor shall be carried back to the service entrance grounding connection or separately derived grounding connection. All equipment grounding conductors, including metallic raceway systems used as such, shall be bonded or joined together in each wiring box or equipment enclosure. Metallic raceways and grounding conductors shall be checked to assure that they are wired or bonded into a common junction. Metallic boxes and enclosures, if used, shall also be bonded to these grounding conductors by an approved means per NFPA 70. When switches, or other utilization devices are installed, any designated grounding terminal on these devices shall also be bonded to the equipment grounding conductor junction with a short jumper.

3.2 WIRING METHODS

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Wiring shall conform to NFPA 70, the contract drawings, and the following specifications. Unless otherwise indicated, wiring shall consist of insulated conductors installed in rigid zinc-coated steel conduit, rigid plastic conduit, electrical metallic tubing <u>and flexible metal clad cable</u>. Where cables and wires are installed in cable trays, they shall be of the type permitted by NFPA 70 for use in such applications. Wire fill in conduits shall be based on NFPA 70 for the type of conduit and wire insulations specified. Wire fill in conduits located in Class I or II hazardous areas shall be limited to 25 percent of the cross sectional area of the conduit.

3.2.1 Conduit and Tubing Systems

Conduit and tubing systems shall be installed as indicated. Conduit sizes shown are based on use of copper conductors with insulation types as described in paragraph WIRING METHODS. Minimum size of raceways shall be 15 mm. Only metal conduits will be permitted when conduits are required for shielding or other special purposes indicated, or when required by conformance to NFPA 70. Nonmetallic conduit and tubing may be used in damp, wet or corrosive locations when permitted by NFPA 70 and the conduit or tubing system is provided with appropriate boxes, covers, clamps, screws or other appropriate type of fittings. Electrical metallic tubing (EMT) may be installed only within buildings. EMT may be installed in concrete and grout in dry locations. EMT installed in concrete or grout shall be provided with concrete tight fittings. EMT shall not be installed in damp or wet locations, or the air space of exterior masonry cavity walls. Bushings, manufactured fittings or boxes providing equivalent means of protection shall be installed on the ends of all conduits and shall be of the insulating type, where required by NFPA 70. Only UL listed adapters shall be used to connect EMT to rigid metal conduit, cast boxes, and conduit bodies. Aluminum conduit may be used only where installed exposed in dry locations. Nonaluminum sleeves shall be used where aluminum conduit passes through concrete floors and firewalls. Penetrations of above grade floor slabs, time-rated partitions and fire walls shall be firestopped in accordance with Section 07840FIRESTOPPING. Except as otherwise specified, IMC may be used as an option for rigid steel conduit in areas as permitted by NFPA 70. Raceways shall not be installed under the firepits of boilers and furnaces and shall be kept 150 mm away from parallel runs of flues, steam pipes and hot-water pipes. Raceways shall be concealed within finished walls, ceilings, and floors unless otherwise shown. Raceways crossing structural expansion joints or seismic joints shall be provided with suitable expansion fittings or other suitable means to compensate for the building expansion and contraction and to provide for continuity of grounding. Wiring installed in shall be suitable for installation in wet locations.

3.2.1.1 Pull Wires

A pull wire shall be inserted in each empty raceway in which wiring is to be installed if the raceway is more than 15 meters in length and contains more than the equivalent of two 90-degree bends, or where the raceway is more than 45 meters in length. The pull wire shall be of No. 14 AWG zinc-coated steel, or of plastic having not less than 1.4 MPa tensile strength. Not less than 254 mm of slack shall be left at each end of the pull wire.

3.2.1.2 Conduit Stub-Ups

Where conduits are to be stubbed up through concrete floors, a short elbow shall be installed below grade to transition from the horizontal run of conduit to a vertical run. A conduit coupling fitting, threaded on the inside shall be installed, to allow terminating the conduit flush with the finished floor. Wiring shall be extended in rigid threaded conduit to equipment, except that where required, flexible conduit may be used 150 mm above the floor. Empty or spare conduit stub-ups shall be plugged flush with the finished floor with a threaded, recessed plug.

3.2.1.3   Below Slab-on-Grade or in the Ground

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Electrical wiring below slab-on-grade shall be protected by a conduit system. Conduit passing vertically through slabs-on-grade shall be rigid steel or IMC. ~~Rigid steel or IMC~~PVC Schedule 40 conduits shall be installed below slab-on-grade or in the earth~~ shall be field wrapped with 0.254 mm thick pipe-wrapping plastic tape applied with a 50 percent overlay, or shall have a factory-applied polyvinyl chloride, plastic resin, or epoxy coating system~~.

3.2.1.4   Installing in Slabs Including Slabs on Grade

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Conduit installed in slabs-on-grade shall be ~~rigid steel or IMC~~PVE Schedule 40. Conduits shall be installed as close to the middle of concrete slabs as practicable without disturbing the reinforcement. Outside diameter shall not exceed 1/3 of the slab thickness and conduits shall be spaced not closer than 3 diameters on centers except at cabinet locations where the slab thickness shall be increased as approved by the Contracting Officer. Where conduit is run parallel to reinforcing steel, the conduit shall be spaced a minimum of one conduit diameter away but not less than 25.4 mm from the reinforcing steel.

3.2.1.5   Changes in Direction of Runs

Changes in direction of runs shall be made with symmetrical bends or cast-metal fittings. Field-made bends and offsets shall be made with an approved hickey or conduit-bending machine. Crushed or deformed raceways shall not be installed. Trapped raceways in damp and wet locations shall be avoided where possible. Lodgment of plaster, dirt, or trash in raceways, boxes, fittings and equipment shall be prevented during the course of construction. Clogged raceways shall be cleared of obstructions or shall be replaced.

3.2.1.6   Supports

Supports shall not be attached to metal decking. Structural steel brackets required to support conduit, cable tray, etc. and equipment, but not shown, shall be provided under this section.

Metallic conduits and tubing,and the support system to which they are attached, shall be securely and rigidly fastened in place to prevent vertical and horizontal movement at intervals of not more than 3 meters and within 900 mm of boxes, cabinets, and fittings, with approved pipe straps, wall brackets, conduit clamps, conduit hangers, threaded C-clamps, beam clamps, or ceiling trapeze. Loads and supports shall be coordinated with supporting structure to prevent damage or deformation to the structure. Loads shall not be applied to joist bridging. Attachment shall be by wood screws or screw-type nails to wood; by toggle bolts on hollow masonry units; by expansion bolts on concrete or brick; by machine screws, welded threaded studs, heat-treated or spring-steel-tension clamps on steel work. Nail-type nylon anchors or threaded studs driven in by a powder charge and provided with lock washers and nuts may be used in lieu of expansion bolts or machine screws. Raceways or pipe straps shall not be welded to steel structures. Cutting the main reinforcing bars in reinforced concrete beams or joists shall be avoided when drilling holes for support anchors. Holes drilled for support anchors, but not used, shall be filled. In partitions of light steel construction, sheet-metal screws may be used. Raceways shall not be supported using wire or nylon ties. Raceways shall be independently supported from the structure. Upper raceways shall not be used as a means of support for lower raceways. Supporting means shall not be shared between electrical raceways and mechanical piping or ducts. Cables and raceways shall not be supported by ceiling grids. Except where permitted by NFPA 70, wiring shall not be supported by ceiling support systems. Conduits shall be fastened to sheet-metal boxes and cabinets with two locknuts where required by NFPA 70, where insulating bushings are used, and where bushings cannot be brought into firm contact with the box; otherwise, a single locknut and bushing may be used. Threadless fittings for electrical metallic tubing shall be of a type approved for the conditions encountered. Additional support for horizontal runs is not required when EMT rests on steel stud cutouts.

3.2.1.7 Exposed Raceways

Exposed raceways shall be installed parallel or perpendicular to walls, structural members, or intersections of vertical planes and ceilings. Raceways under raised floors and above accessible ceilings shall be considered as exposed installations in accordance with NFPA 70 definitions.

3.2.1.8 Exposed Risers

Exposed risers in wire shafts of multistory buildings shall be supported by U-clamp hangers at each floor level, and at intervals not to exceed 3 meters.

3.2.1.9 Exposed Lengths of Conduit, Over 600 Volts

Exposed lengths of conduit containing power conductors operating at more than 600 volts shall have two red bands 50 mm wide spaced 200 mm apart painted near each coupling; the intervening space between the red bands shall be painted white, and on the white space the voltage shall be stenciled in black: 2,470 volts.

3.2.1.10 Communications Raceways

Communications raceways indicated shall be installed in accordance with the previous requirements for conduit and tubing and with the additional requirement that no length of run shall exceed 15 meters for 15 mm and 20 mm sizes, and 30 meters for 25 mm or larger sizes, and shall not contain more than two 90-degree bends or the equivalent. Additional pull or junction boxes shall be installed to comply with these limitations whether or not indicated. Inside radii of bends in conduits of 25 mm size or larger shall not be less than ten times the nominal diameter.

*9

3.2.1.11 Type Metal Clad Cable Installation

Where cable is permitted under the Products Section, the installation of same shall be done in accordance with code and the following:
Cable shall be supported at a minimum of 1200mm on center and in accordance with code. Tie wire is not an acceptable means of support. Cable supports such as Caddy WMX-6, MX-3 or approved equal, and clamps such as Caddy 449 or approved equal shall be used. Where cables are supported by the structure and only need securing in place, then ty-raps will be acceptable. Ty-raps are not acceptable as a means of support. All fittings, hangers and clamps for support and termination of cables shall be of types specifically designed for use with cable, i.e., romex connectors are not

acceptable. Armor of cable shall be removed with rotary cutter device equal to roto-split by Seatek Co., not with hacksaw. Use split "insuliner" sleeves at terminations.

3.2.2   Cable Trays

Cable trays shall be supported in accordance with the recommendations of the manufacturer but at no more than 1.8 meter intervals. Contact surfaces of aluminum connections shall be coated with an antioxidant compound prior to assembly. Adjacent cable tray sections shall be bonded together by connector plates of an identical type as the cable tray sections. The Contractor shall submit the manufacturer's certification that the cable tray system meets all requirements of Article 318 of NFPA 70. The cable tray shall be installed and grounded in accordance with the provisions of Article 318 of NFPA 70. Data submitted by the Contractor shall demonstrate that the completed cable tray systems will comply with the specified requirements. Cable trays shall terminate 250 mm from both sides of smoke and fire partitions. Conductors run through smoke and fire partitions shall be installed in 103 mm rigid steel conduits with grounding bushings, extending 300 mm beyond each side of the partitions. The installation shall be sealed to preserve the smoke and fire rating of the partitions. Penetrations shall be firestopped in accordance with Section 07840 FIRESTOPPING.

3.2.3   Cables and Conductors

Installation shall conform to the requirements of NFPA 70. Covered, bare or insulated conductors of circuits rated over 600 volts shall not occupy the same equipment wiring enclosure, cable, or raceway with conductors of circuits rated 600 volts or less.

3.2.3.1   Cable Systems

Cable systems shall be installed where indicated. Cables shall be installed concealed behind ceiling or wall finish where practicable. Cables shall be threaded through holes bored on the approximate centerline of wood members; notching of surfaces will not be permitted. Sleeves shall be provided through bond beams of masonry-block walls for threading cables through hollow spaces. Exposed cables shall be installed parallel or at right angles to walls or structural members. In rooms or areas not provided with ceiling or wall finish, cables and outlets shall be installed so that a room finish may be applied in the future without disturbing the cables or resetting the boxes. Exposed nonmetallic-sheathed cables less than 1.2 meters above floors shall be protected from mechanical injury by installation in conduit or tubing.

3.2.3.2   Cable Splicing

Splices shall be made in an accessible location. Crimping tools and dies shall be approved by the connector manufacturer for use with the type of connector and conductor.

a. Copper Conductors, 600 Volt and Under: Splices in conductors No. 10 AWG and smaller diameter shall be made with an insulated, pressure-type connector. Splices in conductors No. 8 AWG and larger diameter shall be made with a solderless connector and insulated with tape or heat-shrink type insulating material equivalent to the conductor insulation.

b. Aluminum Conductors, 600 Volt and Under: Splices of aluminum conductors shall be made with a UL listed, solderless, compression-type, aluminum bodied connector, stamped for AL or AL/CU. Aluminum contact surfaces of conductors shall be cleaned with a wire brush and covered with anti-oxidant joint compound prior to making of connections. Any excess joint compound shall be wiped away after installing the connector. Insulate the connection with tape or heat-shrink type insulating material equivalent to the conductor insulation.

c. Greater Than 600 Volt: Cable splices shall be made in accordance with the cable manufacturer's recommendations and Section 16375 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND.

3.2.3.3 Conductor Identification and Tagging

Power, control, and signal circuit conductor identification shall be provided within each enclosure where a tap, splice, or termination is made. Where several feeders pass through a common pull box, the feeders shall be tagged to indicate clearly the electrical characteristics, circuit number, and panel designation. Phase conductors of low voltage power circuits shall be identified by color coding. Phase identification by a particular color shall be maintained continuously for the length of a circuit, including junctions.

a. Color coding shall be provided for service, feeder, branch, and ground conductors. Color shall be green for grounding conductors and white for neutrals; except where neutrals of more than one system are installed in the same raceway or box, other neutral shall be white with colored (not green) stripe. The color coding for 3-phase and single-phase low voltage systems shall be as follows:

   120/208-volt, 3-phase: Black(A), red(B), and blue(C).
   277/480-volt, 3-phase: Brown(A), orange(B), and yellow(C).

b. Conductor phase and voltage identification shall be made by color-coded insulation for all conductors smaller than No. 6 AWG. For conductors No. 6 AWG and larger, identification shall be made by color-coded insulation, or conductors with black insulation may be furnished and identified by the use of half-lapped bands of colored electrical tape wrapped around the insulation for a minimum of 75 mm of length near the end, or other method as submitted by the Contractor and approved by the Contracting Officer.

c. Control and signal circuit conductor identification shall be made by color-coded insulated conductors, plastic-coated self-sticking printed markers, permanently attached stamped metal foil markers, or equivalent means as approved. Control circuit terminals of equipment shall be properly identified. Terminal and conductor identification shall match that shown on approved detail drawings. Hand lettering or marking is not acceptable.

3.3 BOXES AND SUPPORTS

Boxes shall be provided in the wiring or raceway systems where required by NFPA 70 for pulling of wires, making connections, and mounting of devices or fixtures. Pull boxes shall be furnished with screw-fastened covers.

Indicated elevations are approximate, except where minimum mounting heights for hazardous areas are required by NFPA 70. Unless otherwise indicated, boxes for wall switches shall be mounted 1.2 meters above finished floors. Switch and outlet boxes located on opposite sides of fire rated walls shall be separated by a minimum horizontal distance of 600 mm. The total combined area of all box openings in fire rated walls shall not exceed 0.0645 square meters per 9.3 square meters. Maximum box areas for individual boxes in fire rated walls vary with the manufacturer and shall not exceed the maximum specified for that box in UL Elec Const Dir. Only boxes listed in UL Elec Const Dir shall be used in fire rated walls.

3.3.1 Box Applications

Each box shall have not less than the volume required by NFPA 70 for number of conductors enclosed in box. Boxes for metallic raceways shall be listed for the intended use when located in normally wet locations, when flush or surface mounted on outside of exterior surfaces, or when located in hazardous areas. Boxes installed in wet locations and boxes installed flush with the outside of exterior surfaces shall be gasketed. Boxes for mounting lighting fixtures shall be not less than 102 mm square, or octagonal, except smaller boxes may be installed as required by fixture configuration, as approved. Cast-metal boxes with 2.4 mm wall thickness are acceptable. Large size boxes shall be NEMA 1,12, or as shown. Boxes in other locations shall be sheet steel except that aluminum boxes may be used with aluminum conduit, and nonmetallic boxes may be used with nonmetallic conduit and tubing or nonmetallic sheathed cable system, when permitted by NFPA 70. Boxes for use in masonry-block or tile walls shall be square-cornered, tile-type, or standard boxes having square-cornered, tile-type covers.

3.3.2 Brackets and Fasteners

Boxes and supports shall be fastened to wood with wood screws or screw-type nails of equal holding strength, with bolts and metal expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screw or welded studs on steel work. Threaded studs driven in by powder charge and provided with lockwashers and nuts, or nail-type nylon anchors may be used in lieu of expansion shields, or machine screws. Penetration of more than 38.1 mm into reinforced-concrete beams or more than 19.1 mm into reinforced-concrete joists shall avoid cutting any main reinforcing steel. The use of brackets which depend on gypsum wallboard or plasterboard for primary support will not be permitted. In partitions of light steel construction, bar hangers with 25 mm long studs, mounted between metal wall studs or metal box mounting brackets shall be used to secure boxes to the building structure. When metal box mounting brackets are used, additional box support shall be provided on the side of the box opposite the brackets. This additional box support shall consist of a minimum 300 mm long section of wall stud, bracketed to the opposite side of the box and secured by two screws through the wallboard on each side of the stud. Metal screws may be used in lieu of the metal box mounting brackets.

3.3.3 Mounting in Walls, Ceilings, or Recessed Locations

In walls or ceilings of concrete, tile, or other non-combustible material, boxes shall be installed so that the edge of the box is not recessed more than 6 mm from the finished surface. Boxes mounted in combustible walls or ceiling material shall be mounted flush with the finished surface. The use of gypsum or plasterboard as a means of supporting boxes will not be permitted. Boxes installed for concealed wiring shall be provided with suitable extension rings or plaster covers, as required. The bottom of boxes installed in masonry-block walls for concealed wiring shall be mounted flush with the top of a block to minimize cutting of the blocks, and boxes shall be located horizontally to avoid cutting webs of block. Separate boxes shall be provided for flush or recessed fixtures when required by the fixture terminal operating temperature, and fixtures shall be readily removable for access to the boxes unless ceiling access panels are provided.

3.3.4 Installation in Overhead Spaces

In open overhead spaces, cast-metal boxes threaded to raceways need not be separately supported except where used for fixture support; cast-metal boxes having threadless connectors and sheet metal boxes shall be supported directly from the building structure or by bar hangers. Hangers shall not be fastened to or supported from joist bridging. Where bar hangers are used, the bar shall be attached to raceways on opposite sides of the box and the raceway shall be supported with an approved type fastener not more than 600 mm from the box.

3.4 DEVICE PLATES

One-piece type device plates shall be provided for all outlets and fittings. Plates on unfinished walls and on fittings shall be of zinc-coated sheet steel, cast-metal, or impact resistant plastic having rounded or beveled edges. Plates on finished walls shall be of satin finish stainless steel. Screws shall be of metal with countersunk heads, in a color to match the finish of the plate. Plates shall be installed with all four edges in continuous contact with finished wall surfaces without the use of mats or similar devices. Plaster fillings will not be permitted. Plates shall be installed with an alignment tolerance of 1.6 mm. The use of sectional-type device plates will not be permitted. Plates installed in wet locations shall be gasketed and provided with a hinged, gasketed cover, unless otherwise specified.

3.5 RECEPTACLES

3.5.1 Single and Duplex, 15 or 20-ampere, 125 volt

Single and duplex receptacles shall be rated 20 amperes, 125 volts, two-pole, three-wire, grounding type with polarized parallel slots. Bodies shall be of ivory to match color of switch handles in the same room or to harmonize with the color of the respective wall, and supported by mounting strap having plaster ears. Contact arrangement shall be such that contact is made on two sides of an inserted blade. Receptacle shall be side- or back-wired with two screws per terminal. The third grounding pole shall be connected to the metal mounting yoke. Switched receptacles shall be the same as other receptacles specified except that the ungrounded pole of each suitable receptacle shall be provided with a separate terminal. Only the top receptacle of a duplex receptacle shall be wired for switching application. Receptacles with ground fault circuit interrupters shall have the current rating as indicated, and shall be UL Class A type unless otherwise shown. Ground fault circuit protection shall be provided as required by NFPA 70 and as indicated on the drawings.

3.5.2 Floor Outlets

Floor outlets shall be adjustable and each outlet shall consist of a cast-metal body with threaded openings for conduits, adjustable ring, and cover plate with 15 mm or 20 mm threaded flush plug. Each telephone outlet shall consist of a horizontal cast housing with a receptacle as specified. Gaskets shall be used where necessary to ensure a watertight installation. Plugs with installation instructions shall be delivered to the Contracting Officer at the job site for capping outlets upon removal of service fittings.

3.5.3 Weatherproof Applications

Weatherproof receptacles shall be suitable for the environment, damp or wet as applicable, and the housings shall be labeled to identify the allowable use. Receptacles shall be marked in accordance with UL 514A for the type of use indicated; "Damp locations", "Wet Locations", "Wet Location Only When Cover Closed". Assemblies shall be installed in accordance with the manufacturer's recommendations.

3.5.3.1 Damp Locations

Receptacles in damp locations shall be mounted in an outlet box with a gasketed, weatherproof, cast-metal cover plate (device plate, box cover) and a gasketed cap (hood, receptacle cover) over each receptacle opening. The cap shall be either a screw-on type permanently attached to the cover plate by a short length of bead chain or shall be a flap type attached to the cover with a spring loaded hinge.

3.5.3.2 Wet Locations

Receptacles in wet locations shall be installed in an assembly rated for such use whether the plug is inserted or withdrawn, unless otherwise indicated. In a duplex installation, the receptacle cover shall be configured to shield the connections whether one or both receptacles are in use. Assemblies which utilize a self-sealing boot or gasket to maintain wet location rating shall be furnished with a compatible plug at each receptacle location and a sign notifying the user that only plugs intended for use with the sealing boot shall be connected during wet conditions.

3.5.4 Receptacles, 20-Ampere, 250-Volt

Receptacles, single, 20-ampere, 250-volt, shall be ivory molded plastic, two-pole, three-wire or three-pole, four-wire, grounding type complete with appropriate mating cord-grip plug.

3.5.5 Receptacles, 30-Ampere, 125/250-Volt

Receptacles, single, 30-ampere, 125/250-volt, shall be molded-plastic, three-pole, four-wire, grounding type, complete with appropriate mating cord-grip type attachment plug. Each dryer receptacle shall be furnished with a non-detachable power supply cord for connection to the electric clothes dryer. The cord shall be an angle-type 900 mm length of Type SRD range and dryer cable with three No. 10 AWG conductors.

3.5.6 Receptacles, 30-Ampere, 250-Volt

Receptacles, single, 30-ampere, 250-volt, shall be molded-plastic, three-pole, three-wire type, complete with appropriate mating cord-grip plug.

3.5.7 Receptacles, 50-Ampere, 125/250-Volt

Receptacles, single 50-ampere, 125/250-volt, shall be flush, molded plastic, three-pole, four-wire, grounding type. Each range receptacle shall be furnished with a nondetachable power supply cord for connection to the electric range. The cord shall be an angle-type 900 mm length of SRD range and dryer cable with one No. 8 and two No. 6 AWG conductors.

3.5.8 Receptacles, 50-Ampere, 250-Volt

Receptacles, single, 50-ampere, 250-volt, shall be flush molded plastic, three-pole, three-wire type, complete with appropriate mating cord-grip plug.

3.5.9 Special-Purpose or Heavy-Duty Receptacles

Special-purpose or heavy-duty receptacles shall be of the type and of ratings and number of poles indicated or required for the anticipated purpose. Contact surfaces may be either round or rectangular. One appropriate straight or angle-type plug shall be furnished with each receptacle. Locking type receptacles, rated 30 amperes or less, shall be locked by rotating the plug. Locking type receptacles, rated more than 50 amperes, shall utilize a locking ring.

3.6 WALL SWITCHES

Wall switches shall be of the totally enclosed tumbler type. The wall switch handle and switch plate color shall be ivory. Wiring terminals shall be of the screw type or of the solderless pressure type having suitable conductor-release arrangement. Not more than two switches shall be installed in a single-gang position. Switches shall be rated 20-ampere 277-volt for use on alternating current only. Pilot lights indicated shall consist of yoke-mounted candelabra-base sockets rated at 75 watts, 125 volts, and fitted with glass or plastic jewels. A clear 6-watt lamp shall be furnished and installed in each pilot switch. Jewels for use with switches controlling motors shall be green, and jewels for other purposes shall be red. Dimming switches shall be solid-state flush mounted, sized for the loads.

3.7 SERVICE EQUIPMENT

Service-disconnecting means shall be of the POWER SWITCHGEAR ASSEMBLIES INCLUDING SWITCHBOARDS with an external handle for manual operation. When service disconnecting means is a part of an assembly, the assembly shall be listed as suitable for service entrance equipment. Enclosures shall be sheet metal with hinged cover for surface mounting unless otherwise indicated.

3.8 PANELBOARDS

Circuit breakers and switches used as a motor disconnecting means shall be capable of being locked in the open position. Door locks shall be keyed alike. Nameplates shall be as approved. Directories shall be typed to indicate loads served by each circuit and mounted in a holder behind a clear protective covering. Busses shall be copper.

3.8.1 Panelboards

Panelboards shall be circuit breaker equipped as indicated on the drawings.

3.9 FUSES

Equipment provided under this contract shall be provided with a complete set of properly rated fuses when the equipment manufacturer utilize fuses in the manufacture of the equipment, or if current-limiting fuses are required to be installed to limit the ampere-interrupting capacity of circuit breakers or equipment to less than the maximum available fault current at the location of the equipment to be installed. Fuses shall have a voltage rating of not less than the phase-to-phase circuit voltage, and shall have the time-current characteristics required for effective power system coordination. Time-delay and non-time-delay options shall be as shown.

3.9.1 Cartridge Fuses; Noncurrent-Limiting Type

Cartridge fuses of the noncurrent-limiting type shall be Class H, nonrenewable, dual element, time lag type and shall have interrupting capacity of 10,000 amperes. At 500 percent current, cartridge fuses shall not blow in less than 10 seconds.

3.9.2 Cartridge Fuses; Current-Limiting Type

Cartridge fuses, current-limiting type, Class RK1 shall have tested interrupting capacity not less than 200,000 amperes. Fuse holders shall be the type that will reject all Class H fuses.

3.9.3 Continuous Current Ratings (600 Amperes and Smaller)

Service entrance and feeder circuit fuses (600 amperes and smaller) shall be Class RK1, current-limiting, time-delay with 200,000 amperes interrupting capacity.

3.9.4 Continuous Current Ratings (Greater than 600 Amperes)

Service entrance and feeder circuit fuses (greater than 600 amperes) shall be Class L, current-limiting, time-delay with 200,000 amperes interrupting capacity.

3.9.5 Motor and Transformer Circuit Fuses

Motor, motor controller, transformer, and inductive circuit fuses shall be Class RK1 or RK5, current-limiting, time-delay with 200,000 amperes interrupting capacity.

3.10 UNDERGROUND SERVICE

Unless otherwise indicated, interior conduit systems shall be stubbed out 1.5 m beyond the building wall and 600 mm below finished grade, for interface with the exterior service lateral conduits and exterior communications conduits. Outside conduit ends shall be bushed when used for direct burial service lateral conductors. Outside conduit ends shall be capped or plugged until connected to exterior conduit systems. Underground service lateral conductors will be extended to building service entrance and terminated in accordance with the requirements of Section 16375 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND and NFPA 70.

3.11 MOTOR CONTROL

Each motor or group of motors requiring a single control and not controlled from a motor-control center shall be provided under this section with a suitable controller and devices that will perform the functions as specified for the respective motors. Each motor of 93 W or larger shall be provided with thermal-overload protection. Polyphase motors shall have overload protection in each ungrounded conductor. The overload-protection device shall be provided either integral with the motor or controller, or shall be mounted in a separate enclosure. Unless otherwise specified, the protective device shall be of the manually reset type. Single or double pole tumbler switches specifically designed for alternating-current operation only may be used as manual controllers for single-phase motors having a current rating not in excess of 80 percent of the switch rating. Automatic control devices such as thermostats, float or pressure switches may control the starting and stopping of motors directly, provided the devices used are designed for that purpose and have an adequate kilowatt rating. When the automatic-control device does not have such a rating, a magnetic starter shall be used, with the automatic-control device actuating the pilot-control circuit. When combination manual and automatic control is specified and the automatic-control device operates the motor directly, a double-throw, three-position tumbler or rotary switch shall be provided for the manual control; when the automatic-control device actuates the pilot control circuit of a magnetic starter, the latter shall be provided with a three-position selector switch marked MANUAL-OFF-AUTOMATIC. Connections to the selector switch shall be such that only the normal automatic regulatory control devices will be bypassed when the switch is in the Manual position; all safety control devices, such as low- or high-pressure cutouts, high-temperature cutouts, and motor-overload protective devices, shall be connected in the motor-control circuit in both the Manual and the Automatic positions of the selector switch. Control circuit connections to any MANUAL-OFF-AUTOMATIC switch or to more than one automatic regulatory control device shall be made in accordance with wiring diagram approved by the Contracting Officer unless such diagram is included on the drawings. All controls shall be 120 volts or less unless otherwise indicated.

3.11.1 Motor Control Centers

Control centers shall be indoor type and shall contain combination starters and other equipment as indicated. Control centers shall be NEMA ICS 2, Class I, Type B. Each control center shall be mounted on floor sills or mounting channels. Each circuit shall have a suitable metal or laminated plastic nameplate with white cut letters. Combination starters shall be provided with circuit breakers.

3.11.2 Contacts

Unless otherwise indicated, contacts in miscellaneous control devices such as float switches, pressure switches, and auxiliary relays shall have current and voltage ratings in accordance with NEMA ICS 2 for rating designation B300.

3.11.3 Safety Controls

Safety controls for boilers shall be connected to a 2-wire, 120 volt grounded circuit supplied from the associated boiler-equipment circuit. Where the boiler circuit is more than 120 volts to ground, safety controls shall be energized through a two-winding transformer having its 120 volt secondary winding grounded. Overcurrent protection shall be provided in the ungrounded secondary conductor and shall be sized for the load encountered.

3.12 MOTOR-DISCONNECT MEANS

Each motor shall be provided with a disconnecting means when required by NFPA 70 even though not indicated. For single-phase motors, a single or double pole toggle switch, rated only for alternating current, will be acceptable for capacities less than 30 amperes, provided the ampere rating of the switch is at least 125 percent of the motor rating. Switches shall disconnect all ungrounded conductors.

3.13 TRANSFORMER INSTALLATION

3.14 LIGHTING FIXTURES, LAMPS AND BALLASTS

This paragraph shall cover the installation of lamps, lighting fixtures and ballasts in interior or building mounted applications.

3.14.1 Lamps

Lamps of the type, wattage, and voltage rating indicated shall be delivered to the project in the original cartons and installed just prior to project completion. Lamps installed and used for working light during construction shall be replaced prior to turnover to the Government if more than 15% of their rated life has been used. Lamps shall be tested for proper operation prior to turn-over and shall be replaced if necessary with new lamps from the original manufacturer. 10% spare lamps of each type, from the original manufacturer, shall be provided.

3.14.2 Lighting Fixtures

Fixtures shall be as shown and shall conform to the following specifications and shall be as detailed on the drawings. Illustrations shown on the drawings are indicative of the general type desired and are not intended to restrict selection to fixtures of any particular manufacturer. Fixtures of similar designs and equivalent energy efficiency, light distribution and brightness characteristics, and of equal finish and quality will be acceptable if approved. In suspended acoustical ceilings with fluorescent fixtures, the fluorescent emergency light fixtures shall be furnished with self-contained battery packs.

3.14.2.1 Accessories

Accessories such as straps, mounting plates, nipples, or brackets shall be provided for proper installation.

3.14.2.2 Ceiling Fixtures

Ceiling fixtures shall be coordinated with and suitable for installation in, on or from the ceiling as shown. Installation and support of fixtures shall be in accordance with NFPA 70 and manufacturer's recommendations. Where seismic requirements are specified herein, fixtures shall be supported as shown or specified. Recessed fixtures shall have adjustable fittings to permit alignment with ceiling panels. Recessed fixtures installed in fire-resistive ceiling construction shall have the same fire rating as the ceiling or shall be provided with fireproofing boxes having materials of the same fire rating as the ceiling, in conformance withUL Elec Const Dir. Surface-mounted fixtures shall be suitable for fastening to the ceiling panel structural supports.

3.14.2.3   Fixtures for Installation in Grid Type Ceilings

Fixtures for installation in grid type ceilings which are smaller than a full tile shall be centered in the tile. 305 by 1219 mm fixtures shall be mounted along the grid rail as shown. Work above the ceiling shall be coordinated among the trades to provide the lighting layout shown. Fixtures mounted to the grid shall have trim exactly compatible with the grid. Contractor shall coordinate trims with ceiling trades prior to ordering fixtures. Metric fixtures shall be designed to fit the metric grid specified. Fixtures in continuous rows shall be coordinated between trades prior to ordering. Fixtures shall be mounted using independent supports capable of supporting the entire weight of the fixture. No fixture shall rest solely on the ceiling grid. Recessed fixtures installed in seismic areas should be installed utilizing specially designed seismic clips. Junction boxes shall be supported at four points.

3.14.2.4   Suspended Fixtures

Suspended fixtures shall be provided with swivel hangers or hand-straights so that they hang plumb. Pendants, rods, or chains 1.2 meters or longer excluding fixture shall be braced to prevent swaying using three cables at 120 degrees of separation. Suspended fixtures in continuous rows shall have internal wireway systems for end to end wiring and shall be properly aligned to provide a straight and continuous row without bends, gaps, light leaks or filler pieces. Aligning splines shall be used on extruded aluminum fixtures to assure hairline joints. Steel fixtures shall be supported to prevent "oil-canning" effects. Fixture finishes shall be free of scratches, nicks, dents, and warps, and shall match the color and gloss specified. Pendants shall be finished to match fixtures. Aircraft cable shall be stainless steel. Canopies shall be finished to match the ceiling and shall be low profile unless otherwise shown. Maximum distance between suspension points shall be 3.1 meters or as recommended by the manufacturer, whichever is less.

Suspended fixtures installed in seismic areas shall have 45% swivel hangers and shall be located with no obstructions within the 45% range in all directions. The stem, canopy and fixture shall be capable of 45% swing.

3.14.3   Ballasts

Remote type ballasts or transformers, where indicated, shall be mounted in a well ventilated, easily accessible location, within the maximum operating distance from the lamp as designated by the manufacturer.

3.15   EQUIPMENT CONNECTIONS

Wiring not furnished and installed under other sections of the specifications for the connection of electrical equipment as indicated on the drawings shall be furnished and installed under this section of the specifications. Connections shall comply with the applicable requirements of paragraph WIRING METHODS. Flexible conduits 2 m or less in length shall be provided to all electrical equipment subject to periodic removal, vibration, or movement and for all motors. All motors shall be provided with separate grounding conductors. Liquid-tight conduits shall be used in damp or wet locations.

3.15.1   Motors and Motor Control

Motors, motor controls, and motor control centers shall be installed in accordance with NFPA 70, the manufacturer's recommendations, and as indicated. Wiring shall be extended to motors, motor controls, and motor control centers and terminated.

3.15.2 Installation of Government-Furnished Equipment

Wiring shall be extended to the equipment and terminated.

3.16 CIRCUIT PROTECTIVE DEVICES

The Contractor shall calibrate, adjust, set and test each new adjustable circuit protective device to ensure that they will function properly prior to the initial energization of the new power system under actual operating conditions.

3.17 PAINTING AND FINISHING

Field-applied paint on exposed surfaces shall be provided under Section 09900 PAINTING, GENERAL.

3.18 FIELD TESTING

Field testing shall be performed in the presence of the Contracting Officer. The Contractor shall notify the Contracting Officer 7 days prior to conducting tests. The Contractor shall furnish all materials, labor, and equipment necessary to conduct field tests. The Contractor shall perform all tests and inspection recommended by the manufacturer unless specifically waived by the Contracting Officer. The Contractor shall maintain a written record of all tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results. All field test reports will be signed and dated by the Contractor.

3.18.1 Safety

The Contractor shall provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. The Contractor shall replace any devices or equipment which are damaged due to improper test procedures or handling.

3.18.2 Ground-Resistance Tests

The resistance of the grounding grid shall be measured using the fall-of-potential method defined in IEEE Std 81. Soil resistivity in the area of the grid shall be measured concurrently with the grid measurements. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.

a. Single rod electrode - 5 ohms.

b. Grid electrode - 5 ohms.

3.18.3 Ground-Grid Connection Inspection

All below-grade ground-grid connections will be visually inspected by the Contracting Officer before backfilling. The Contractor shall notify the Contracting Officer 8 hours before the site is ready for inspection.

3.18.4 Cable Tests

The Contractor shall be responsible for identifying all equipment and devices that could be damaged by application of the test voltage and ensuring that they have been properly disconnected prior to performing insulation resistance testing. An insulation resistance test shall be performed on all low and medium voltage cables after the cables are installed in their final configuration and prior to energization. The test voltage shall be 500 volts DC applied for one minute between each conductor and ground and between all possible combinations of conductors. The minimum value of resistance shall be:

R in megohms = (rated voltage in kV + 1) x 304.8/(length of cable in meters)

Each cable failing this test shall be repaired or replaced. The repaired cable system shall then be retested until failures have been eliminated.

3.18.4.1 Medium Voltage Cable Tests

a. Continuity test.

b. Insulation resistance test.

c. DC high-potential test.

3.18.4.2 Low Voltage Cable Tests

a. Continuity test.

b. Insulation resistance test.

3.18.5 Motor Tests

a. Phase rotation test to ensure proper directions.

b. Operation and sequence of reduced voltage starters.

c. High potential test on each winding to ground.

d. Insulation resistance of each winding to ground.

e. Vibration test.

f. Dielectric absorption test on motor and starter.

3.18.6 Dry-Type Transformer Tests

The following field tests shall be performed on all dry-type transformers 15 kVA and above.

a. Insulation resistance test phase-to-ground, each phase.

b. Turns ratio test.

3.18.7 Circuit Breaker Tests

The following field tests shall be performed on circuit breakers.

3.18.7.1 Circuit Breakers, Low Voltage

a. Insulation resistance test phase-to-phase, all combinations.

b. Insulation resistance test phase-to-ground, each phase.

c. Closed breaker contact resistance test.

d. Manual and electrical operation of the breaker.

3.18.7.2 Circuit Breakers, Molded Case

a. Insulation resistance test phase-to-phase, all combinations.

b. Insulation resistance test phase-to-ground, each phase.

c. Closed breaker contact resistance test.

d. Manual operation of the breaker.

3.18.8 Motor Control Centers

a. Insulation resistance test phase-to-phase, all combinations.

b. Insulation resistance test phase-to-ground, each phase.

c. Manual and electrical operational tests.

3.19 OPERATING TESTS

After the installation is completed, and at such time as the Contracting Officer may direct, the Contractor shall conduct operating tests for approval. The equipment shall be demonstrated to operate in accordance with the specified requirements. An operating test report shall be submitted in accordance with paragraph FIELD TEST REPORTS.

3.20 FIELD SERVICE

3.20.1 Onsite Training

The Contractor shall conduct a training course for the operating staff as designated by the Contracting Officer. The training period shall consist of a total of 8 hours of normal working time and shall start after the system is functionally completed but prior to final acceptance tests. The course instruction shall cover pertinent points involved in operating, starting, stopping, servicing the equipment, as well as all major elements of the operation and maintenance manuals. Additionally, the course instructions shall demonstrate all routine maintenance operations. A 20 VHS 8 format video tape of the entire training shall be submitted.

3.20.2 Installation Engineer

After delivery of the equipment, the Contractor shall furnish one or more field engineers, regularly employed by the equipment manufacturer to supervise the installation of equipment, assist in the performance of the onsite tests, oversee initial operations, and instruct personnel as to the operational and maintenance features of the equipment.

3.21 ACCEPTANCE

Final acceptance of the facility will not be given until the Contractor has successfully completed all tests and after all defects in installation, material or operation have been corrected.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 16 - ELECTRICAL

SECTION 16475

COORDINATED POWER SYSTEM PROTECTION

10/96

-- End of Section Table of Contents --

SECTION 16475

COORDINATED POWER SYSTEM PROTECTION
10/96

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.11	(1987; R 1993) Instrumental Transformers for Revenue Metering, 10 kV BIL Through 350 kV BIL (0.6 kV NSV Through 69 kV NSV)
ANSI C37.16	(1997) Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors - Preferred Ratings, Related Requirements, and Application Recommendations
ANSI C37.46	(1981; R 1992) Power Fuses and Fuse Disconnecting Switches

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(1997) National Electrical Safety Code
IEEE C37.2	(1996) Electrical Power System Device Function Numbers and Contract Designations
IEEE C37.13	(1990; R 1995) Low-Voltage AC Power Circuit Breakers Used in Enclosures
IEEE C37.90	(1989; R 1994) Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C57.13	(1993) Instrument Transformers
IEEE Std 242	(1986; R 1991) IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
IEEE Std 399	(1997) Recommended Practice for Industrial and Commercial Power Systems Analysis

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA AB 1	(1993) Molded Case Circuit Breakers and Molded Case Switches
NEMA FU 1	(1986) Low Voltage Cartridge Fuses
NEMA ICS 1	(1993) Industrial Controls and Systems
NEMA ICS 2	(1993) Industrial Control and Systems, Controllers, Contractors Overload Relays Rated not More Then 2,00 Volts AC or 750 Volts DC
NEMA ICS 3	(1993) Industrial Control and Systems Factory Built Assemblies
NEMA ICS 6	(1993) Industrial Control and Systems, Enclosures
NEMA SG 2	(1993) High Voltage Fuses
NEMA SG 3	(1995) Power Switching Equipment
NEMA SG 5	(1995) Power Switchgear Assemblies

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1999) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 198B	(1995) Class H Fuses
UL 198C	(1986; Rev thru Feb 1998) High-Interrupting-Capacity Fuses, Current-Limiting Types
UL 198D	(1995) Class K Fuses
UL 198E	(1988; Rev Jul 1988) Class R Fuses
UL 198H	(1988; Rev thru Nov 1993) Class T Fuses
UL 486E	(1994; Rev Feb 1997) Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors
UL 489	(1996; Rev thru Dec 1998) Molded-Case Circuit Breakers Molded-Case Switches, and Circuit-Breaker Enclosures
UL 508	(1993; Rev thru Oct 1997) Industrial Control Equipment

UL 845	(1995; Rev Feb 1996) Motor Control Centers
UL 877	(1993; Rev thru May 1997) Circuit Breakers and Circuit-Breaker Enclosures for Use in Hazardous (Classified) Locations

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Fault Current Analysis; G, AE
Protective Device Coordination Study; G, AE

The study along with protective device equipment submittals. No time extensions or similar contact modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed will be based on recommendations of this study. The Government shall not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study.

Equipment; G, AE

Data consisting of manufacturer's time-current characteristic curves for individual protective devices, recommended settings of adjustable protective devices, and recommended ratings of non-adjustable protective devices.

System Coordinator; G, AE

Verification of experience and license number, of a registered Professional Engineer with at least four years of current experience in the design of coordinated power system protection. Experience data shall include at least five references for work of a magnitude comparable to this contract, including points of contact, addresses and telephone numbers. This engineer must perform items required by this section to be performed by a registered Professional Engineer.

Protective Relays; G, AE

Data shall including calibration and testing procedures and instructions pertaining to the frequency of calibration, inspection, adjustment, cleaning, and lubrication.

Installation; G, AE

Procedures including diagrams, instructions, and precautions required to properly install, adjust, calibrate, and test the devices and equipment.

SD-06 Test Reports

Field Testing; G, RE

The proposed test plan, prior to field tests. Plan shall consist of complete field test procedure including tests to be performed, test equipment required, and tolerance limits, including complete testing and verification of the ground fault protection equipment, where used. Performance test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall indicate the final position of controls.

SD-07 Certificates

Devices and Equipment; G, RE

Certificates certifying that all devices or equipment meet the requirements of the contract documents.

1.3 SYSTEM DESCRIPTION

The power system covered by this specification consists of:

Main primary and secondary short circuit ampacity and respective relay characteristics.
Circuit breakers.
All breaker and relay final settings.
Base quantities selected.
Impedance source data.
Calculation methods and tabulations.
Voltage drop calculations.
One-line diagrams and impedance diagrams.
Coordination plots.
Conclusion and recommendations.
Ground fault studies for each system.

1.4 QUALIFICATIONS

1.4.1 System Coordinator

System coordination, recommended ratings and settings of protective devices, and design analysis shall be accomplished by a registered professional electrical power engineer with a minimum of two years of current experience in the coordination of electrical power systems.

1.4.2 System Installer

Calibration, testing, adjustment, and placing into service of the protective devices shall be accomplished by a manufacturer's product field service engineer or independent testing company with a minimum of two years of current product experience in protective devices.

1.5 DELIVERY, STORAGE, AND HANDLING

Devices and equipment shall be visually inspected when received and prior to acceptance from conveyance. Stored items shall be protected from the environment in accordance with the manufacturer's published instructions. Damaged items shall be replaced.

PART 2 PRODUCTS

2.1 STANDARD PRODUCT

Protective devices and equipment shall be the standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory utility type use for at least two years prior to bid opening.

2.2 NAMEPLATES

Nameplates shall be provided to identify all protective devices and equipment. Nameplate information shall be in accordance with NEMA AB 1, NEMA SG 3, or NEMA SG 5 as applicable.

2.3 CORROSION PROTECTION

Metallic materials shall be protected against corrosion. Ferrous metal hardware shall be zinc or chrome-plated.

2.4 MOTOR CONTROLS AND MOTOR CONTROL CENTERS

Motor controls and motor control centers shall be in accordance with NEMA ICS 1, NEMA ICS 2, NEMA ICS 3 and NEMA ICS 6, and UL 508and UL 845.

2.4.1 Motor Starters

Combination starters shall be provided with circuit breakers.

2.4.2 Thermal-Overload Protection

Each motor of 93 W or larger shall be provided with thermal-overload protection. Polyphase motors shall have overload protection in each ungrounded conductor. The overload-protection device shall be provided either integral with the motor or controller, or shall be mounted in a separate enclosure. Unless otherwise specified, the protective device shall be of the manually reset type. Single or double pole tumbler switches specifically designed for alternating-current operation only may be used as manual controllers for single-phase motors having a current rating not in excess of 80 percent of the switch rating.

2.4.3 Low-Voltage Motor Overload Relays

2.4.3.1 General

Thermaloverload relays shall conform to NEMA ICS 2 and UL 508. Overload protection shall be provided either integral with the motor or controller, and shall be rated in accordance with the requirements of NFPA 70. Standard units shall be used for motor starting times up to 7 second. Slow units shall be used for motor starting times from 8 to 12 seconds.

2.4.3.2 Construction

Manual reset type thermal relays shall be melting alloy construction. Automatic reset type relays shall be bimetallic construction. Magnetic current relays shall consist of a contact mechanism and a dash pot mounted on a common frame.

2.4.3.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Trip current ratings shall be established by selection of the replaceable overload device and shall not be adjustable. Where the controller is remotely-located or difficult to reach, an automatic reset, non-compensated overload relay shall be provided. Manual reset overload relays shall be provided otherwise, and at all locations where automatic starting is provided. Where the motor is located in a constant ambient temperature, and the thermal device is located in an ambient temperature that regularly varies by more than minus 10 degrees C, an ambient temperature-compensated overload relay shall be provided.

2.4.4 Automatic Control Devices

2.4.4.1 Direct Control

Automatic control devices (such as thermostats, float or pressure switches) which control the starting and stopping of motors directly shall be designed for that purpose and have an adequate kilowatt rating.

2.4.4.2 Pilot-Relay Control

Where the automatic-control device does not have such a rating, a magnetic starter shall be used, with the automatic-control device actuating the pilot-control circuit.

2.4.4.3 Manual/Automatic Selection

a. Where combination manual and automatic control is specified and the automatic-control device actuates the pilot control circuit of a magnetic starter, the magnetic starter shall be provided with a three-position selector switch marked MANUAL-OFF-AUTOMATIC.

b. Connections to the selector switch shall only allow the normal automatic regulatory control devices to be bypassed when the switch is in the Manual position; all safety control devices, such as low-or high-pressure cutouts, high-temperature cutouts, and motor-overload protective devices, shall be connected in the motor-control circuit in both the Manual and the Automatic positions of the selector switch. Control circuit connections to any MANUAL-OFF-AUTOMATIC switch or to more than one automatic regulatory control device shall be made in accordance with wiring diagram approved by the contracting Officer unless such diagram is included on the drawings. All controls shall be 120 volts or less unless otherwise indicated.

2.4.5 Motor Control Centers

Control centers shall be indoor type and shall contain combination starters and other equipment as indicated. Control centers shall be NEMA ICS 2, Class II, Type B. Each control center shall be mounted on floor sills or mounting channels. Each circuit shall have a suitable metal or laminated plastic nameplate with white cut letters. Motor control centers shall be provided with a full-length ground bus bar.

2.5 LOW-VOLTAGE FUSES

2.5.1 General

Low-voltage fuses shall conform to NEMA FU 1. Time delay and nontime delay options shall be as specified. Equipment provided under this contract shall be provided with a complete set of properly rated fuses when the equipment manufacturer utilizes fuses in the manufacture of the equipment, or if current-limiting fuses are required to be installed to limit the ampere-interrupting capacity of circuit breakers or equipment to less than the maximum available fault current at the location of the equipment to be installed. Fuses shall have a voltage rating of not less than the phase-to-phase circuit voltage, and shall have the time-current characteristics requires for effective power system coordination.

2.5.2 Cartridge Fuses; Noncurrent-Limiting Type

Cartridge fuses of the noncurrent-limiting type shall be Class H, nonrenewable, dual element, time lag type and shall have interrupting capacity of 10,000 amperes. Class H Fuses shall conform to UL 198B. At 500 percent current, cartridge fuses shall not blow in less than 10 seconds. Cartridge fuses shall be used for circuits rated in excess of 30 amperes, 125 volts, except where current-limiting fuses are indicated.

2.5.3 Cartridge Fuses; Current-Limiting Type

Cartridge fuses, current-limiting type, Class RK1 shall have tested interrupting capacity not less than 200,000 amperes. Fuse holders shall be the type that will reject Class H fuses.

a. Class J fuses shall conform to UL 198C.

b. Class K fuses shall conform to UL 198D.

c. Class R fuses shall conform to UL 198E.

d. Class T fuses shall conform to UL 198H.

2.5.3.1 Continuous Current Ratings (600 amperes and smaller)

Service entrance and feeder circuit fuses (600 amperes and smaller) shall be Class J, current-limiting, nontime-delay with 200,000 amperes interrupting capacity.

2.5.3.2 Continuous Current Ratings (greater than 600 amperes)

Service entrance and feeder circuit fuses (greater than 600 amperes) shall be Class L, current-limiting, nontime-delay with 200,000 amperes interrupting capacity.

2.5.3.3 Motor and Transformer Circuit Fuses

Motor, motor controller, transformer, and inductive circuit fuses shall be Class RK1 or RK5, current-limiting, time-delay with 200,000 amperes interrupting capacity.

2.6 MEDIUM-VOLTAGE AND HIGH-VOLTAGE FUSES

2.6.1 General

Medium-voltage and high-voltage fuses shall conform to NEMA SG 2 and shall be distribution fuse cutouts or power fuses, E-rated, C-rated, or R-rated current-limiting fuses as shown.

2.6.2 Construction

Units shall be suitable for outdoor use. Fuses shall have integral blown-fuse indicators. All ratings shall be clearly visible.

2.6.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Continuous-current ratings shall be as shown.

2.6.3.1 Fuse Cutouts

Medium-voltage fuses and cutouts shall comply with NEMA SG 2 and shall be of the loadbreak type construction rated 15kV and of the heavy-duty type. Open-link cutouts are not acceptable. Fuses shall be either indicating or dropout type. Fuse ratings shall be as indicated. Fuses cutouts shall be equipped with mounting brackets suitable for the indicated installations.

2.6.3.2 Power Fuses

Current-limiting power fuses shall have ratings in accordance with ANSI C37.46 and as follows:

a. Nominal voltage....................................12,470

b. Rated maximum voltage..............................15,000

c. Maximum symmetrical interrupting capacity..........40,000

d. Rated continuous current...........................600

e. BIL..95kV

2.6.3.3 E-Rated, Current-Limiting Power Fuses

E-rated, current-limiting, power fuses shall conform to ANSI C37.46.

2.6.3.4 C-Rated, Current-Limiting Fuses

C-rated, current-limiting, power fuses shall open in 1000 seconds at currents between 170 and 240 percent of the C rating.

2.6.3.5 R-Rated, Current-Limiting Fuses

R-rated, current-limiting, fuses shall be used with medium-voltage motor controllers only. R-rated fuses shall conform to ANSI C37.46.

2.7 MOTOR SHORT-CIRCUIT PROTECTOR (MSCP)

2.7.1 General

Motor short-circuit protectors shall conform to UL 508 and shall be provided as shown. Protectors shall be used only as part of a combination motor controller which provides coordinated motor branch-circuit overload and short-circuit protection, and shall be rated in accordance with the requirements of NFPA 70.

2.7.2 Construction

Motor short-circuit protector bodies shall be constructed of high temperature, dimensionally stable, long life, nonhygroscopic materials. Protectors shall fit special MSCP mounting clips and shall not be interchangeable with any commercially available fuses. Protectors shall have 100 percent one-way interchangeability within the A-Y letter designations. All ratings shall be clearly visible.

2.7.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Letter designations shall be A through Y for motor controller Sizes 0, 1, 2, 3, 4, and 5, with 100,000 amperes interrupting capacity rating. Letter designations shall correspond to controller sizes as follows:

CONTROLLER SIZE	MSCP DESIGNATION
NEMA 0	A-N
NEMA 1	A-P
NEMA 2	A-S

CONTROLLER SIZE	MSCP DESIGNATION
NEMA 3	A-U
NEMA 4	A-W
NEMA 5	A-Y

2.8 MOLDED-CASE CIRCUIT BREAKERS

2.8.1 General

Molded-case circuit breakers shall conform to NEMA AB 1 and UL 489. Circuit breakers may be installed in panelboards, switchboards, enclosures, motor control centers, or combination motor controllers. Circuit breakers and circuit breaker enclosures located in hazardous (classified) areas shall conform to UL 877.

2.8.2 Construction

Molded-case circuit breakers shall be assembled as an integral unit in a supporting and enclosing housing of glass reinforced insulating material providing high dielectric strength. Circuit breakers shall be suitable for mounting and operating in any position. Lugs shall be listed for copper conductors only in accordance with UL 486E. Single-pole circuit breakers shall be full module size with not more than one pole per module. Multi-pole circuit breakers shall be of the common-trip type having a single operating handle such that an overload or short circuit on any one pole will result in all poles opening simultaneously. Sizes of 100 amperes or less may consist of single-pole breakers permanently factory assembled into a multi-pole unit having an internal, mechanical, nontamperable common-trip mechanism and external handle ties. All circuit breakers shall have a quick-make, quick-break overcenter toggle-type mechanism, and the handle mechanism shall be trip-free to prevent holding the contacts closed against a short-circuit or sustained overload. All circuit breaker handles shall assume a position between "ON" and "OFF" when tripped automatically. All ratings shall be clearly visible.

2.8.3 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. The interrupting rating of the circuit breakers shall be at least equal to the available short-circuit current at the line terminals of the circuit breaker and correspond to the UL listed integrated short-circuit current rating specified for the panelboards and switchboards. Molded-case circuit breakers shall have nominal voltage ratings, maximum continuous-current ratings, and maximum short-circuit interrupting ratings in accordance with NEMA AB 1. Ratings shall be coordinated with system X/R ratio.

2.8.4 Cascade System Ratings

Circuit breakers used in series combinations shall be in accordance with UL 489. Equipment, such as switchboards and panelboards, which house series-connected circuit breakers shall be clearly marked accordingly. Series combinations shall be listed in the UL Recognized Component Directory under "Circuit Breakers-Series Connected."

2.8.5   Thermal-Magnetic Trip Elements

Thermal magnetic circuit breakers shall be provided as shown. Automatic operation shall be obtained by means of thermal-magnetic tripping devices located in each pole providing inverse time delay and instantaneous circuit protection. The instantaneous magnetic trip shall be adjustable and accessible from the front of all circuit breakers on frame sizes above 150 amperes.

2.8.6   Solid-State Trip Elements

Solid-state circuit breakers shall be provided as shown. All electronics shall be self-contained and require no external relaying, power supply, or accessories. Printed circuit cards shall be treated to resist moisture absorption, fungus growth, and signal leakage. All electronics shall be housed in an enclosure which provides protection against arcs, magnetic interference, dust, and other contaminants. Solid-state sensing shall measure true RMS current with error less than one percent on systems with distortions through the 13th harmonic. Peak or average actuating devices are not acceptable. Current sensors shall be toroidal construction, encased in a plastic housing filled with epoxy to protect against damage and moisture and shall be integrally mounted on the breaker. Where indicated on the drawings, circuit breaker frames shall be rated for 100 percent continuous duty. Circuit breakers shall have tripping features as shown on the drawings and as described below:

a. Long-time current pick-up, adjustable from 50 percent to 100 percent of continuous current rating.

b. Adjustable long-time delay.

c. Short-time current pick-up, adjustable from 1.5 to 9 times long-time current setting.

d. Adjustable short-time delay.

e. Short-time I square times t switch.

f. Instantaneous current pick-up, adjustable from 1.5 to 9 times long-time current setting.

g. Ground-fault pick-up, adjustable from 20 percent to 60 percent of sensor rating, but in no case greater than 1200 amperes. Sensing of ground-fault current at the main bonding jumper or ground strap shall not be permitted. Zone-selective interlocking shall be provided as shown.

h. Adjustable ground-fault delay.

i. Ground-fault I square times t switch.

j. Overload and Short-circuit and Ground-fault trip indicators shall be provided.

2.8.7 Current-Limiting Circuit Breakers

Current-limiting circuit breakers shall be provided as shown. Current-limiting circuit breakers shall limit the let-through I square times t to a value less than the I square times t of one-half cycle of the symmetrical short-circuit current waveform. On fault currents below the threshold of limitation, breakers shall provide conventional overload and short-circuit protection. Integrally-fused circuit breakers shall not be used.

2.8.8 SWD Circuit Breakers

Circuit breakers rated 15 amperes or 20 amperes and intended to switch 277 volts or less fluorescent lighting loads shall be marked "SWD."

2.8.9 HACR Circuit Breakers

Circuit breakers 60 amperes or below, 240 volts, 1-pole or 2-pole, intended to protect multi-motor and combination-load installations involved in heating, air conditioning, and refrigerating equipment shall be marked "Listed HACR Type."

2.8.10 Motor Circuit Protectors (MCP)

Motor circuit protectors shall conform to NEMA AB 1 and UL 489 and shall be provided as shown. MCPs shall consist of an adjustable instantaneous trip circuit breaker in conjunction with a combination motor controller which provides coordinated motor circuit overload and short-circuit protection. Motor Circuit Protectors shall be rated in accordance with NFPA 70.

2.9 LOW-VOLTAGE POWER CIRCUIT BREAKERS

2.9.1 Construction

Low-voltage power circuit breakers shall conform to IEEE C37.13, ANSI C37.16, and NEMA SG 3 and shall be three-pole, single-throw, stored energy, electrically operated, with drawout mounting. Solid-state trip elements which require no external power connections shall be provided. Circuit breakers shall have an open/close contact position indicator, charged/discharged stored energy indicator, primary disconnect devices, and a mechanical interlock to prevent making or breaking contact of the primary disconnects when the circuit breaker is closed. Control voltage shall be 120 V ac. The circuit breaker enclosure shall be suitable for its intended location.

2.9.2 Ratings

Voltage ratings shall be not less than the applicable circuit voltage. Circuit breakers shall be rated for 100 percent continuous duty and shall have trip current ratings and frame sizes as shown. Nominal voltage ratings, maximum continuous-current ratings, and maximum short-circuit interrupting ratings shall be in accordance with ANSI C37.16. Tripping features shall be as follows:

a. Long-time current pick-up, adjustable from 50 percent to 100 percent of sensor current rating.

b. Adjustable long-time delay.

c. Short-time current pick-up, adjustable from 1.5 to 9 times long-time current setting.

d. Adjustable short-time delay.

e. Short-time I square times t switch.

f. Instantaneous current pick-up, adjustable from 1.5 to 9 times long-time current setting.

g. Ground-fault pick-up, adjustable from 20 percent to 60 percent of sensor rating, but in no case greater than 1200 amperes. Sensing of ground-fault current at the main bonding jumper or ground strap shall not be permitted. Zone-selective interlocking shall be provided as shown.

h. Adjustable ground-fault delay.

i. Ground-fault I square times t switch.

j. Overload and Short-circuit and Ground-fault trip indicators shall be provided.

2.10 INSTRUMENT TRANSFORMERS

2.10.1 General

Instrument transformers shall comply with ANSI C12.11 and IEEE C57.13. Instrument transformers shall be configured for mounting in/on the device to which they are applied. Polarity marks on instrument transformers shall be visually evident and shown on the drawings.

2.10.2 Current Transformers

Unless otherwise indicated, bar, wound, or window-type transformers are acceptable; and except for window-type units installed over insulated buses, transformers shall have a BIL rating consistent with the rated BIL of the associated switchgear or electric power apparatus bushings, buses or conductors. Current transformers shall have the indicated ratios. The continuous thermal-current rating factor shall be not less than 1.5. Other thermal and mechanical ratings of current transformers and their primary leads shall be coordinated with the design of the circuit breaker and shall be not less than the momentary rating of the associated circuit breaker. Circuit protectors shall be provided across secondary leads of the current transformers to prevent the accidental open-circuiting of the transformers while energized. Each terminal of each current transformer shall be connected to a short-circuiting terminal block in the circuit interrupting mechanism cabinet, power transformer terminal cabinet, and in the associated instrument and relay cabinets.

2.10.2.1   Current Transformers for Power Transformers

Multi-ratio bushing type current transformers shall be provided internally around power transformer bushings as shown. Single-ratio units shall have a minimum metering accuracy class of 0.6B-0.5.

2.10.2.2   Current Transformers for kW Hour and Demand Metering (Low Voltage)

Current transformers shall conform to IEEE C57.13. Current transformers with a metering accuracy Class of 0.3 through 1.3, with a minimum RF of 1.33 at 30 degrees C, with 600-volt insulation, and 10 kV BIL shall be provided. Butyl-molded, window-type current transformers mounted on the transformer low-voltage bushings shall be provided. Route current transformer leads in a location as remote as possible from the power transformer secondary cables to permit current measurements to be taken with hook-on-ammeters in the current transformer cabinet shall be provided.

2.10.2.3   Voltage Transformers

Voltage transformers shall have indicated ratios. Units shall have an accuracy rating of 95%. Voltage transformers shall be of the drawout type having current-limiting fuses in both primary and secondary circuits. Mechanical interlocks shall prevent removal of fuses, unless the associated voltage transformer is in a drawout position. Voltage transformer compartments shall have hinged doors.

2.11   COORDINATED POWER SYSTEM PROTECTION

Analyses shall be prepared to demonstrate that the equipment selected and system constructed meet the contract requirements for ratings, coordination, and protection. They shall include a load flow analysis, a fault current analysis, and a protective device coordination study. The studies shall be performed by a registered professional engineer with demonstrated experience in power system coordination in the last three years. The Contractor shall provide a list of references complete with points of contact, addresses and telephone numbers. The selection of the engineer is subject to the approval of the Contracting Officer.

2.11.1   Scope of Analyses

The fault current analysis, and protective device coordination study shall begin at: the source bus and extend down to system buses where fault availability is 10,000 amperes (symmetrical) for building/facility 600 volt level distribution buses. The source bus and extend through outgoing breakers for main electric supply substations. The nearest upstream device in the existing source system and extend through the downstream devices at the load end.

2.11.2   Determination of Facts

The time-current characteristics, features, and nameplate data for each existing protective device shall be determined and documented. The Contractor shall coordinate with the Government for fault current availability at the site. The Contractor shall utilize the fault current availability indicated as a basis for fault current studies.

2.11.3 Single Line Diagram

A single line diagram shall be prepared to show the electrical system buses, devices, transformation points, and all sources of fault current (including generator and motor contributions). A fault-impedance diagram or a computer analysis diagram may be provided. Each bus, device or transformation point shall have a unique identifier. If a fault-impedance diagram is provided, impedance data shall be shown. Location of switches, breakers, and circuit interrupting devices shall be shown on the diagram together with available fault data, and the device interrupting rating.

2.11.4 Fault Current Analysis

2.11.4.1 Method

The fault current analysis shall be performed in accordance with methods described in IEEE Std 242, and IEEE Std 399.

2.11.4.2 Data

Actual data shall be utilized in fault calculations. Bus characteristics and transformer impedance shall be those proposed. Data shall be documented in the report.

2.11.4.3 Fault Current Availability

Balanced three-phase fault, bolted line-to-line fault, and line-to-ground fault current values shall be provided at each voltage transformation point and at each power distribution bus. The maximum and minimum values of fault available at each location shall be shown in tabular form on the diagram or in the report.

2.11.5 Coordination Study

The study shall demonstrate that the maximum possible degree of selectivity has been obtained between devices specified, consistent with protection of equipment and conductors from damage from overloads and fault conditions. The study shall include a description of the coordination of the protective devices in this project. A written narrative shall be provided describing: which devices may operate in the event of a fault at each bus; the logic used to arrive at device ratings and settings; situations where system coordination is not achievable due to device limitations (an analysis of any device curves which overlap); coordination between upstream and downstream devices; and relay settings. Recommendations to improve or enhance system reliability, and detail where such changes would involve additions or modifications to the contract and cost damages (addition or reduction) shall be provided. Composite coordination plots shall be provided on log-log graph paper.

2.11.6 Study report

a. The report shall include a narrative describing: the analyses performed; the bases and methods used; and the desired method of coordinated protection of the power system.

b. The study shall include descriptive and technical data for existing devices and new protective devices proposed. The data shall include manufacturers published data, nameplate data, and definition of the fixed or adjustable features of the existing or new protective devices.

c. The report shall document utility company data including system voltages, fault MVA, system X/R ratio, time-current characteristic curves, current transformer ratios, and relay device numbers and settings; and existing power system data including time-current characteristic curves and protective device ratings and settings.

d. The report shall contain fully coordinated composite time-current characteristics curves for each bus in the system, as required to ensure coordinated power system protection between protective devices or equipment. The report shall include recommended ratings and settings of all protective devices in tabulated form.

e. The report shall provide the calculation performed for the analyses, including computer analysis programs utilized. The name of the software package, developer, and version number shall be provided.

PART 3 EXECUTION

3.1 VERIFICATION OF DIMENSIONS

After becoming familiar with details of the work, the Contractor shall verify dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing any work.

3.2 INSTALLATION

Protective devices shall be installed in accordance with the manufacturer's published instructions and in accordance with the requirements of NFPA 70 and IEEE C2.

3.3 FIELD TESTING

3.3.1 General

Field testing shall be performed in the presence of the Contracting Officer. The Contractor shall notify the Contracting Officer 7 days prior to conducting tests. The Contractor shall furnish all materials, labor, and equipment necessary to conduct field tests. The Contractor shall perform all tests and inspections recommended by the manufacturer unless specifically waived by the Contracting Officer. The Contractor shall maintain a written record of all tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results.

3.3.2 Safety

The Contractor shall provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. The Contractor shall replace any devices or equipment which are damaged due to improper test procedures or handling.

3.3.3 Molded-Case Circuit Breakers

Circuit breakers shall be visually inspected, operated manually, and connections checked for tightness. Current ratings shall be verified and adjustable settings incorporated in accordance with the coordination study.

3.3.4 Power Circuit Breakers

3.3.4.1 General

The Contractor shall visually inspect the circuit breaker and operate the circuit breaker manually; adjust and clean primary contacts in accordance with manufacturer's published instructions; check tolerances and clearances; check for proper lubrication; and ensure that all connections are tight. For electrically operated circuit breakers, the Contractor shall verify operating voltages on closing and tripping coils. The Contractor shall verify fuse ratings in control circuits; electrically operate the breaker, where applicable; and implement settings in accordance with the coordination study.

3.3.4.2 Power Circuit Breaker Tests

All power circuit breakers shall be tested in accordance with ANSI C37.50

3.3.5 Protective Relays

Protective relays shall be visually and mechanically inspected, adjusted, tested, and calibrated in accordance with the manufacturer's published instructions. Tests shall include pick-up, timing, contact action, restraint, and other aspects necessary to ensure proper calibration and operation. Relay settings shall be implemented in accordance with the coordination study. Relay contacts shall be manually or electrically operated to verify that the proper breakers and alarms initiate. Relaying current transformers shall be field tested in accordance with IEEE C57.13.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 16 - ELECTRICAL

SECTION 16528A

EXTERIOR LIGHTING

05/01

-- End of Section Table of Contents --

SECTION 16528A

EXTERIOR LIGHTING
05/01

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C80.1	(1995) Rigid Steel Conduit - Zinc Coated
ANSI C119.1	(1986; R 1997) Sealed Insulated Underground Connector Systems Rated 600 Volts

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 36/A 36M	(2000) Carbon Structural Steel
ASTM A 48M	(1994el) Gray Iron Castings (Metric)
ASTM A 123/A 123M	(2000) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 153/A 153M	(2000) Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM B 117	(1997) Operating Salt Spray (Fog) Apparatus
ASTM C 478	(1997) Precast Reinforced Concrete Manhole Sections
ASTM D 1654	(1992) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(1997) National Electrical Safety Code
IEEE C62.41	(1991; R 1995) Surge Voltages in Low-Voltage AC Power Circuits
IEEE C136.13	(1987; R 1997) Metal Brackets for Wood Poles
IEEE Std 81	(1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

(Part 1)

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA OS 1	(1996) Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports
NEMA OS 2	(1998) Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports
NEMA RN 1	(1998) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC 6	(1990) PVC and ABS Plastic Utilities Duct for Underground Installation
NEMA TC 9	(1990) Fittings for ABS and PVC Plastic Utilities Duct for Underground Installation

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1999) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 6	(1997) Rigid Metal Conduit
UL 44	(1999) Thermoset-Insulated Wires and Cables
UL 98	(1994; Rev thru Jun 1998) Enclosed and Dead-Front Switches
UL 467	(1993; Rev thru Apr 1999) Grounding and Bonding Equipment
UL 486A	(1997; Rev thru Dec 1998) Wire Connectors and Soldering Lugs for Use with Copper Conductors
UL 514A	(1996; Rev Dec 1999) Metallic Outlet Boxes
UL 514B	(1996; Rev Oct 1998) Fittings for Conduit and Outlet Boxes
UL 514C	(1996; Rev thru Dec 1999) Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 651	(1995; Rev thru Oct 1998) Schedule 40 and 80 Rigid PVC Conduit
UL 651A	(1995; Rev thru Apr 1998) Type EB and A Rigid PVC Conduit and HDPE Conduit
UL 854	(1996; Rev Oct 1999) Service-Entrance Cables
UL 886	(1994; Rev thru Apr 1999) Outlet Boxes and

	Fittings for Use in Hazardous (Classified) Locations
UL 1449	(1996; Rev thru Dec 1999) Transient Voltage Surge Suppressors

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

*8

SD-03 Product Data; G, AE

a. Fluorescent lighting fixtures

b. Fluorescent electronic ballasts

c. Fluorescent electromagnetic ballasts

d. Fluorescnet lamps

e. High-intensity-discharge (HID) lighting fixtures

f. HID ballasts

g. Metal-halide lamps

As-Built Drawings; G, RE

Final as-built drawings shall be finished drawings on mylar or vellum and shall be delivered with the final test report.

SD-03 Product Data

Equipment and Materials~~; G, AE~~

Data published by the manufacturer of each item on the list of equipment and material, to permit verification that the item proposed is of the correct size, properly rated or applied, or is otherwise suitable for the application and fully conforms to the requirements specified.

Spare Parts~~; G, RE~~

Spare parts data for each item of material and equipment specified, after approval of detail drawings for materials and equipment, and not later than 4 months before the date of beneficial occupancy. The data shall include a complete list of parts, special tools, and supplies, with current unit prices and sources of supply.

Operating Test; G, RE

Test procedures and reports for the Operating Test. After receipt by the Contractor of written approval of the test procedures, the Contractor shall schedule the tests. The final test procedures report shall be delivered after completion of the tests.

Ground Resistance Measurements; G, RE

The measured resistance to ground of each separate grounding installation, indicating the location of the rods, the resistance of the soil in ohms per millimeter and the soil conditions at the time the measurements were made. The information shall be in writing.

SD-10 Operation and Maintenance Data

Lighting System; G, RE

A draft copy of the operation and maintenance manuals, prior to beginning the tests for use during site testing. Final copies of the manuals as specified bound in hardback, loose-leaf binders, within 30 days after completing the field test. The draft copy used during site testing shall be updated with any changes required, prior to final delivery of the manuals. Each manual's contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of each subcontractor installing equipment and systems, and nearest service representatives for each item of equipment for each system. The manuals shall have a table of contents and tab sheets. Tab sheets shall be placed at the beginning of each chapter or section and at the beginning of each appendix. The final copies delivered after completion of the field test shall include modifications made during installation checkout and acceptance.

1.3 SYSTEM DESCRIPTION

1.3.1 Lighting System

The lighting system shall be configured as specified and shown. The system shall include all fixtures, hardware, poles, cables, connectors, adapters and appurtenances needed to provide a fully functional lighting system.

1.3.2 Electrical Requirements

The equipment shall operate from a voltage source as shown, plus or minus 10 percent, and 60 Hz, plus or minus 2 percent.

1.3.3 Interface Between Lighting System and Power Distribution

Conductors shall include all conductors extending from the load side of the primary and secondary power panels that serve assessment lighting equipment.

1.3.4 Nameplates

Each major component of equipment shall have a nonferrous metal or engraved plastic nameplate which shall show, as a minimum, the manufacturer's name and address, the catalog or style number, the electrical rating in volts, and the capacity in amperes or watts.

1.3.5 Standard Products

Materials and equipment shall be standard products of manufacturer regularly engaged in the manufacture of such products. Items of equipment shall essentially duplicate equipment that has been in satisfactory use at least 2 years prior to bid opening.

1.3.6   Tamper Provisions

Enclosures, cabinets, housings (other than luminaire housings), boxes, raceways, conduits, and fittings having hinged doors or removable covers, and which contain any part of the security lighting system (including power sources), shall be provided with corrosion-resistant tamper switches. For pull or junction boxes which contain no splices or connections the covers may be protected by 6.4 mm   tack welds on four sides of each cover. Labels shall be affixed to indicate they contain no connections.

1.4   CORROSION PROTECTION

1.4.1   Ferrous Metal Materials

1.4.1.1   Hardware

Ferrous metal hardware shall be hot-dip galvanized in accordance with ASTM A 153/A 153M and ASTM A 123/A 123M.

1.4.1.2   Equipment

Equipment and component items, including but not limited to metal poles and ferrous metal luminaires not hot-dip galvanized or porcelain enamel finished, shall be provided with corrosion-resistant finishes which shall withstand 120 hours of exposure to the salt spray test specified in ASTM B 117 without loss of paint or release of adhesion of the paint primer coat to the metal surface in excess of 1.6 mm   from the test mark. The scribed test mark and test evaluation shall have a rating of not less than 7 in accordance with TABLE 1, (procedure A) of ASTM D 1654. Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill galvanized sheet steel shall be coated with a zinc rich paint conforming to the manufacturer's standard.

1.4.2   Finishing

Painting required for surfaces not otherwise specified and finish painting of items only primed at the factory, shall be as specified in Section 09900 PAINTING, GENERAL.

1.4.3   ELECTRONIC BALLAST WARRANTY

Furnish the electronic ballast manufacturer's warranty. The warranty period shall not be less than 5 years from the date of manufacture of the electronic ballast. Ballast assembly in the lighting fixture, transportation, and on-site storage shall not exceed 12 months, thereby permitting 4 years of the ballast 5 year warranty to be in service and energized. The warranty shall state that the malfunctioning ballast shall be exchanged by the manufacturer and promptly shipped to the using Government facility. The replacement ballast shall be identical to, or an improvement upon, the original design of the malfunctioning ballast.

PART 2   PRODUCTS

2.1 Flourcent Fixtures

UL 1570. Fluorescent fixtures shall have electronic ballasts unless specifically indicated otherwise.

2.1.1 Fluorescent Lamp Electronic Ballasts

The electronic ballast shall as a minimum meet the following characteristics:

a. Ballast shall comply with UL 935, NEMA C82.11, and NFPA 70 unless specified otherwise. Ballast shall be designed for the wattage of the lamps used in the indicated application. Ballasts shall be designed to operate on the voltage system to which they are connected.

b. Power factor shall be 0.95 (minimum).

c. Ballast shall operate at a frequency of 20,000 Hertz (minimum).

d. Ballast shall have light regulation of plus or minus 10 percent lumen output with a plus or minus 10 percent input voltage regulation. Ballast shall have 10 percent flicker (maximum) using any compatible lamp.

e. Ballast shall be UL listed Class P with a sound rating of "A."

f. Ballast enclosure size shall conform to standards of electromagnetic ballasts. Ballast shall have circuit diagrams and lamp connections displayed on ballast packages. Ballast shall operate lamps in a parallel circuit configuration that permits the operation of remaining lamps if one or more lamps fail or are removed.

g. Ballast shall operate in an instant start mode.

h. Electronic ballast shall have a full replacement warranty of 5 years from date of manufacture as specified in paragraph entitled "Electronic Ballast Warranty" herein.

2.1.2 Compact Fluorescent Fixtures

Compact fluorescent fixtures shall be manufactured specifically for compact fluorescent lamps with ballasts integral to the fixture. Providing assemblies designed to retrofit incandescent fixtures is prohibited except when specifically indicated for renovation of existing fixtures. Fixtures shall use lamps as indicated.

2.2 HIGH-INTENSITY-DISCHARGE (HID) LIGHTING FIXTURES

UL 1572. Provide HID fixtures with tempered glass lenses when using metal-halide lamps.

2.2.1 HID Ballasts

UL 1029 and NEMA C82.4 and shall be constant wattage autotransformer (CWA) or regulator, high power factor type. Provide single-lamp ballasts which shall have a minimum starting temperature of minus 30 degrees C. Ballasts shall be:

a. Designed to operate on the voltage system to which they are connected.

b. Designed for installation in a normal ambient temperature of 40 degrees C.

c. Constructed so that open circuit operation will not reduce the average life.

2.2.2 Metal-Halide Lamps

a. 70 watt conforming to ANSI C78.1381

b. 100 watt conforming to NEMA C78.1382

c. 150 watt conforming to NEMA C78.1384

d. 175 watt conforming to NEMA C78.1377

e. 250 watt conforming to NEMA C78.1378

f. 400 watt conforming to NEMA C78.1375

g. 1000 watt conforming to NEMA C78.1376

2.3 RECESS- AND FLUSH-MOUNTED FIXTURES

Provide type that can be relamped from the bottom. Access to ballast shall be from the bottom. Trim for the exposed surface of flush-mounted fixtures shall be as indicated.

2.4 STANDARD PRODUCT

Material and equipment shall be the standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Items of the same classification shall be identical including equipment, assemblies, parts, and components.

2.5 BRACKET ARMS

2.5.1 On Aluminum

Poles shall be provided with bracket arms of the davit style and of the length indicated on drawings. Bracket arms shall conform to the design of the pole provided. The bracket arms shall be capable of supporting the equipment to be mounted on it with the maximum wind and ice loading encountered at the site. Strength of bracket arms shall be in accordance with IEEE C136.13. Steel brackets shall be galvanized. Wood bracket arms shall not be used.

2.6 CABLE

The Contractor shall provide all wire and cable not indicated as government furnished equipment. Wire and cable components shall be able to withstand the jobsite environment for a minimum of 20 years.

2.6.1   Insulated Cable

Cable shall be type USE conforming to UL 854, with copper conductors and type RHW or XHHW insulation conforming to UL 44, and shall include green ground conductor. Cable shall be provided with insulation of a thickness not less than that given in column A of TABLE 15.1 of UL 854. Cable shall be rated 600 volts. Parts of the cable system such as splices and terminations shall be rated not less than 600 volts. The size and number of conductors and the number of cables shall be as indicated. Conductors larger than No. 8 AWG shall be stranded.

2.7   CABLE SPLICES AND CONNECTORS

Cable splices and connectors shall conform to UL 486A. Underground splices and connectors shall also conform to the requirements of ANSI C119.1.

2.8   CABLE BOXES

Boxes and covers shall be made of cast iron with zinc coated or aluminized finish, and shall be of the sizes indicated on drawings. The minimum inside dimensions shall be not less than 304.8 mm   square by 152.4 mm deep and not less than required to house the cable splice. A suitable gasket shall be installed between the box and cover for watertightness. A sufficient number of screws shall be installed to hold the cover in place along the entire surface of contact. Grounding lugs shall be provided.

2.9   MANHOLES, HANDHOLES, AND PULLBOXES

Manholes, handholes, and pullboxes shall be as indicated. Strength of manholes, handholes, and pullboxes and their frames and covers shall conform to the requirements of IEEE C2. Precast concrete manholes shall have the required strength established by ASTM C 478. Frames and covers for manholes shall be made of gray cast iron. A machine-finished seat shall be provided to ensure a matching joint between frame and cover. Cast iron shall comply with ASTM A 48M , Class 30B, minimum. Handholes for low voltage cables installed in parking lots, sidewalks, and turfed areas shall be from an aggregate consisting of sand and with continuous woven glass strands having an overall compressive strength of at least 69 MPa and a flexural strength of at least 34.5 MPa   Pullbox and handhole covers in parking lots, sidewalks, and turfed areas shall be of the same material as the box. Concrete pullboxes shall consist of precast reinforced concrete boxes, extensions, bases, and covers.

2.10   CONDUIT, DUCTS AND FITTINGS

2.10.1   Conduit, Rigid Steel

Rigid steel conduit shall conform to ANSI C80.1 and UL 6.

2.10.2   Conduit Coatings

Underground metallic conduit and fittings shall be coated with a plastic resin system conforming to NEMA RN 1, Type 40. Epoxy systems may also be used.

2.10.3   Conduit Fittings and Outlets

2.10.3.1   Boxes, Metallic Outlets

NEMA OS 1 and UL 514A.

2.10.3.2 Boxes, Nonmetallic, Outlet and Flush-Device Boxes and Covers

NEMA OS 2 and UL 514C.

2.10.3.3 Boxes, Switch (Enclosed), Surface Mounted

UL 98.

2.10.3.4 Fittings for Conduit and Outlet Boxes

UL 514B.

2.10.3.5 Fittings, PVC, for Use with Rigid PVC Conduit and Tubing

UL 514B.

2.10.4 Non-Metallic Duct

Non-metallic duct lines and fittings utilized for underground installation shall be suitable for the application. Duct shall be thick-wall, single, round-bore type. Material of one type shall be used. Acrylonitrile-butadiene-styrene (ABS) duct shall conform to NEMA TC 6and NEMA TC 9. High-density conduit shall conform to UL 651A. Schedule 40 polyvinyl chloride (PVC) shall conform to UL 651. Plastic utility duct and fittings manufactured without a UL label or listing shall be provided with a certification as follows: "The materials are suitable for use with 75 degree C wiring. No reduction of properties in excess of that specified for materials with a UL label or listing will be experienced if samples of the finished product are operated continuously under the normal conditions that produce the highest temperature in the duct."

2.11 GROUND RODS

Ground rods shall be of copper clad steel conforming to UL 467 not less than 15.9 mm in diameter by 3.1 m in length of the sectional type driven full length into earth.

2.12 Aluminum Poles

Aluminum poles and brackets for walkway lighting shall have a uniform satin finish to match fixtures and shall not be painted. Manufacturer's standard provision shall be made for protecting the finish during shipment and installation. Minimum protection shall consist of spirally wrapping each pole shaft with protective paper secured with tape, and shipping small parts in boxes.

a. Shafts shall be round and of seamless construction. The wall thickness shall be at least 4.8 mm. Exterior surfaces shall be free of protuberances, dents, cracks, and discoloration. Material for shafts shall be 6063 aluminum alloy; after fabrication, the alloy shall have a T6 temper. Tops of shafts shall be fitted with a round or tapered cover. Bases shall be anchor bolt mounted, made of cast aluminum alloy 356-T6, and shall be machined to receive the lower end of shafts. Joints between shafts and bases shall be welded. Bases shall be provided with four holes, spaced 90 degrees apart, for anchorage.

b. Hardware, except anchor bolts, shall be either 2024-T4 anodized aluminum alloy or stainless steel.

2.12.1 Anchor Bolts

Anchor bolts shall be the pole manufacturer's standard, but not less than necessary to meet the pole wind and ice loading, herein and other specified design requirements.

2.13 In-Line Fuse

An in-line fuse shall be provided for each fixture, and shall consist of a fuse and a UL approved waterproof fuse holder rated at 30 amperes, 600 volts , with insulated boots. Fuse rating shall be 600 volts.

PART 3 EXECUTION

3.1 General

The Contractor shall install all system components, including government furnished equipment, and appurtenances in accordance with the manufacturer's instructions, IEEE C2, and contract documents, and shall furnish necessary hardware, fixtures, cables, wire, connectors, interconnections, services, and adjustments required for a complete and operable system.

3.2 ENCLOSURE PENETRATIONS

Enclosure penetrations shall be from the bottom unless the system design requires penetrations from other directions. Penetrations of interior enclosures involving transitions of conduit from interior to exterior, and penetrations on exterior enclosures shall be sealed with rubber silicone sealant to preclude the entry of water. The conduit riser shall terminate in a hot-dipped galvanized metal cable terminator. The terminator shall be filled with an approved sealant as recommended by the cable manufacturer, and in such a manner that the cable is not damaged.

3.3 PREVENTION OF CORROSION

3.3.1 Aluminum

Aluminum shall not be used in contact with earth or concrete, and where connected to dissimilar metal, shall be protected by approved fittings and treatment.

3.3.2 Steel Conduits

Steel conduits shall not be installed within concrete slabs-on-grade. Steel conduits installed underground or under slabs-on-grade, or penetrating slabs-on-grade, shall be field wrapped with 254 micrometers thick pipe-wrapping plastic tape applied with a 50 percent overlap, or shall have a factory-applied plastic resin, epoxy coating. Zinc coating may be omitted from steel conduit which has a factory-applied epoxy coating.

3.3.3 Cold Galvanizing

Field welds and/or brazing on factory galvanized boxes, enclosures, conduits, etc. shall be coated with a cold galvanized paint containing at least 95 percent zinc by weight.

3.4 CABLE INSTALLATION

Cable and all parts of the cable system such as splices and terminations shall be rated not less than 600 volts. The size and number of conductors and the number of cables shall be as indicated. Conductors larger than No. 8 AWG shall be stranded. Each circuit shall be identified by means of fiber or nonferrous metal tags, or approved equal, in each handhole and junction box, and at each terminal.

3.4.1 Splices

Splices below grade shall be made with nonpressure-filled resin systems using transparent, interlocking, self-venting, longitudinally split plastic molds. Splices above grade shall be made with sealed insulated pressure connectors and shall provide insulation and jacket equal to that of the cable. In order to prevent moisture from entering the splice, jackets shall be cut back to expose the required length of insulation between the jacket and the tapered end of the insulation.

3.4.2 Installation in Duct Lines

Ground and neutral conductors shall be installed in duct with the associated phase conductors. Cable splices shall be made in handholes only.

3.4.3 Trenching

Trenches shall be excavated to the depths required to provide the minimum cable cover. The bottom of the trench shall be smooth and free of stones and sharp objects. Where the bottom of the trench consists of material other than sand or earth, an additional 75 mm layer shall be removed and replaced by a 75 mm layer of sand or stone-free earth compacted to the approximate density of the surrounding firm soil. The cables shall be unreeled in place along the side of or in the trench and carefully placed on the sand or earth bottom. Pulling cables into a direct-burial trench from a fixed reel position will not be permitted. Where cables cross, a separation of at least 75 mm shall be provided, unless the cables are protected by nonmetallic conduit sleeves at the crossing. The radius of bends in cables shall be not less than 12 times the diameter of the cable. Cables shall not be left under longitudinal tension. The first layer of backfill shall be 150 mm thick and shall consist of sand or stone-free earth. One-inch untreated planks, not less than 200 mm in width, or approved equal protection, shall be placed end to end along the cable run, approximately 75 mm above the cable. A 0.127 mm (5 mil), brightly colored plastic tape not less than 75 mmin width and suitably inscribed at not more than 3 m on centers, or other approved dig-in warning indication, shall be placed approximately 300 mm below finished grade levels of trenches. Selected backfill of sand or stone-free earth shall be provided to a minimum depth of 75 mm above cables.

3.4.4 Requirements for Installation in Duct

Where indicated on drawing, cable shall be installed in duct lines. Ground and neutral conductors shall be installed in duct with the associated phase conductors. The segments of direct-burial cable that cross under new railroad tracks, roads, or paving exceeding 1.5 m in width, shall be installed in plastic, or rubber duct encased in concrete in accordance with paragraph DUCT LINES. Pulling of cable into conduit from a fixed reel position will be permitted. At interfaces with direct-burial cable, the direct-burial cable shall be centered in the entrance to the duct, using an approved waterproof, nonhardening mastic compound to facilitate the centering. Where crossing existing railroad tracks, coated rigid steel conduit shall be installed under the tracks, in lieu of concrete-encased duct, in accordance with paragraph DUCT LINES. Installation shall be in accordance with NFPA 70 and the regulations of the railroad.

3.4.5 Location of Cable Splices

Splices in direct-burial cable will not be permitted in runs of 150 m or less or at intervals of less than 150 m in longer runs except as required for taps. Where cable splices in shorter intervals are required to avoid obstructions or damage to the cable, the location shall be as approved. Cable splices shall be installed in cable boxes or concrete handholes.

3.4.6 Markers

Cable and cable splice markers shall be located near the ends of cables, at each cable splice, approximately every 120 m along the cable run, and at changes in direction of the cable run. Markers need not be placed along cables laid in relatively straight lines between lighting poles that are spaced less than 120 m apart. Markers shall be placed approximately 600 mm to the right of the cable or cable splice when facing the longitudinal axis of the cable in the direction of the electrical load. The marker shall be concrete with a 28 day compressive strength of 17 MPa in accordance with Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE. The letter "C" shall be impressed in the top of each marker.

3.4.7 Warning Tape

Direct burial cable shall be placed below a plastic warning tape buried in the same trench or slot. A 0.127 mm (5 mil) brightly colored plastic tape, not less than 75 mm in width and suitably inscribed at not more than 3 m on centers with a continuous metallic backing and a corrosion-resistant 0.0254 mm (1 mil) metallic foil core to permit easy location of the buried cable, shall be placed approximately 300 mm below finished grade.

3.5 DUCT LINES

3.5.1 Requirements

Numbers and size of ducts shall be as indicated. Duct lines shall be laid with a minimum slope of 100 mm per 30 m. Depending on the contour of the finished grade, the high point may be at a terminal, a manhole, a handhole, or between manholes or handholes. Short radius manufactured 90 degree duct bends may be used only for pole or equipment risers, unless specifically indicated as acceptable. The minimum manufactured bend radius shall be 450 mm for ducts of less than 80 mm in diameter, and 900 mm for duct 80 mm or greater in diameter. Otherwise, long sweep bends having a minimum radius of 7.6 m shall be used for a change of direction of more than 5 degrees, either horizontally or vertically. Both curved and straight sections may be used to form long sweep bends, but the maximum curve used shall be 30 degrees and manufactured bends shall be used. Ducts shall be provided with end bells when duct lines terminate in manholes or handholes.

3.5.2 Treatment

Ducts shall be kept clean of concrete, dirt, or foreign substances during construction. Field cuts requiring tapers shall be made with proper tools and shall match factory tapers. A coupling recommended by the duct manufacturer shall be used when an existing duct is connected to a duct of different material or shape. Ducts shall be stored to avoid warping and deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Ducts shall be thoroughly cleaned before being laid. Plastic ducts shall be stored on a flat surface and protected from the direct rays of the sun.

3.5.3 Concrete Encasement

Ducts requiring concrete encasements shall comply with NFPA 70 except that electrical duct bank configurations for ducts 150 mm in diameter shall be determined by calculation and as shown on the drawings. Duct line encasements shall be monolithic construction. Where a connection is made to a previously poured encasement, the new encasement shall be well bonded or doweled to the existing encasement. At any point, except railroad and airfield crossings, tops of concrete encasements shall not be less than the cover requirements listed in NFPA 70. At railroad and airfield crossings, duct lines shall be encased with concrete and reinforced as indicated to withstand specified surface landings. Tops of concrete encasement shall not be less than 1.5 m below tops of rails or airfield paving unless otherwise indicated. Where ducts are jacked under existing pavement, rigid steel conduit shall be installed. To protect the corrosion-resistant conduit coating, predrilling or installing conduit inside a larger iron pipe sleeve (jack-and-sleeve) is required. For crossings of existing railroads and airfield pavements greater than 15 m in length, the predrilling method or the jack-and-sleeve method shall be used. Separators or spacing blocks shall be made of steel, concrete, plastic, or a combination of these materials placed not more than 1.2 m on centers. Ducts shall be securely anchored to prevent movement during the placement of concrete, and joints shall be staggered at least 150 mm vertically.

3.5.4 Nonencased Direct-Burial

Top of duct lines shall be below the frost line depth of 1200 mm, but not less than 900 mm below finished grade and shall be installed with a minimum of 75 mm of earth around each duct, except that between adjacent electric power and communication ducts, 300 mm of earth is required. Bottom of trenches shall be graded toward manholes or handholes and shall be smooth and free of stones, soft spots, and sharp objects. Where bottoms of trenches comprise materials other than sand, a 75 mm layer of sand shall be laid first and compacted to approximate densities of surrounding firm soil before installing ducts. Joints in adjacent tiers of duct shall be vertically staggered at least 150 mm. The first 150 mm layer of backfill cover shall be sand compacted as previously specified. The rest of the excavation shall be backfilled and compacted in 75 to 150 mm layers. Duct banks may be held in alignment with earth. However, high tiered banks shall use a wooden frame or equivalent form to hold ducts in alignment prior to backfilling.

3.5.5 Installation of Couplings

Joints in each type of duct shall be made up in accordance with the manufacturer's recommendation for the particular type of duct and coupling selected and as approved.

3.5.5.1 Plastic Duct

Duct joints shall be made by brushing a plastic solvent on insides of plastic coupling fittings and on outsides of duct ends. Each duct and fitting shall then be slipped together with a quick 1/4 turn to set the joint tightly.

3.5.6 Concrete

Concrete work shall be as specified in Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE. Concrete shall be plain, 17 MPa at 28 days, except that reinforced concrete shall be 21 MPa at 28 days. Duct line encasement shall be of monolithic construction. Where a connection is made to an existing duct line, the concrete encasement shall be well bonded or doweled to the existing encasement.

3.5.7 Duct Line Markers

Duct line markers shall be provided as indicated. In addition to markers, a 0.127 mm (5 mil) brightly colored plastic tape, not less than 75 mm in width and suitably inscribed at not more than 3 m on centers with a continuous metallic backing and a corrosion-resistant 0.0254 mm (1 mil) metallic foil core to permit easy location of the duct line, shall be placed approximately 300 mm below finished grade levels of such lines.

3.6 HANDHOLES

The exact locations shall be determined after carefully considering the locations of other utilities, grading, and paving. Exact locations shall be approved before construction is started.

3.6.1 Construction

Handholes shall be constructed as indicated on drawings, including appurtenances. Top, walls, and bottom shall consist of reinforced concrete. Walls and bottom shall be of monolithic construction. Concrete shall be 21 MPa at 28 days. Precast concrete handholes having the same strength and inside dimensions as cast-in-place concrete handholes may be used. In paved areas, the top of entrance covers shall be flush with the finished surface of the paving. In unpaved areas, the top of entrance covers shall be approximately 15 mm above the finished grade. Where finished grades are in cut areas, unmortared brick shall be installed between the top of handhole and entrance frame to temporarily elevate the entrance cover to existing grade level. Where duct lines enter walls, the sections of duct may be cast in the concrete or may enter the wall through a suitable opening. The openings around entering duct lines shall be caulked tight with lead wool or other approved material.

3.6.2 Appurtenances

The following appurtenances shall be provided for each handhole.

3.6.3 Cable Pulling-In Irons

A cable pulling-in iron shall be installed in the wall opposite each duct line entrance.

3.6.4 Ground Rods

In each handhole, at a convenient point close to the wall, a ground rod conforming to paragraph GROUNDING shall be driven into the earth before the floor is poured; approximately 100 mm of the ground rod shall extend above the floor after pouring. When precast concrete units are used, the top of the ground rod may be below the floor; a No. 1/0 AWG copper ground conductor shall be brought inside through a watertight sleeve in the wall.

3.7 POLE INSTALLATION

Pole lengths shall provide a luminaire mounting height as indicated on drawings. Luminaire mounting height may be increased by the height of the transformer base where required. The mount interfaces shall have ac power connected, and the pole wiring harness shall be connected to the luminaire. Light poles shall not be installed outside the site or inside the perimeter zone. Pole installation shall conform to the manufacturer's recommendations, NFPA 70, and IEEE C2. Poles shall be set straight and plumb.

3.7.1 Concrete Foundations

Concrete foundations shall have anchor bolts accurately set in the foundation using a template supplied by the pole manufacturer. Once the concrete has cured, the pole shall be set on the foundation, leveled on the foundation bolts, and secured with the holding nuts. The space between the foundation and the pole base shall be grouted. Concrete and grout work shall conform to Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE. Concrete shall be 21 MPa at 28 days.

3.7.2 Rigid Steel Conduit Ells

Rigid steel conduit ells shall be provided at all poles. Rigid steel conduit shall be connected to the ells and shall extend to a minimum height of 3 m above grade. Rigid steel conduit ells shall be provided for wood poles, where required

3.7.3 Aluminum Installation

Poles shall be mounted on cast-in-place or power-installed screw foundations. Concrete poles shall be embedded in accordance with the details shown. Conduit elbows shall be provided for cable entrances into pole interiors.

3.7.3.1 Cast-In-Place Foundations

Concrete foundations, sized as indicated, shall have anchor bolts accurately set in foundations using templates supplied by the pole manufacturer. Concrete work and grouting is specified in Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE. After the concrete has cured, pole anchor bases shall be set on foundations and leveled by shimming between anchor bases and foundations or by setting anchor bases on leveling nuts and grouting. Poles shall be set plumb. Anchor bolts shall be the manufactures standard, and not less than necessary to meet the pole wind loading and other specified design requirements.

3.7.3.2 Power-Installed Screw Foundations

Power-installed screw foundations having the required strength mounting bolt and top plate dimensions may be utilized. Screw foundations shall be of at least 6.4 mm thick structural steel conforming to ASTM A 36/A 36M and hot-dip galvanized in accordance with ASTM A 123/A 123M. Conduit slots in screw foundation shafts and top plates shall be marked to indicate orientation. Design calculations indicating adequate strength shall be approved before installation of any screw foundation.

3.8 GROUNDING

Grounding shall be in conformance with NFPA 70, the contract drawings, and the following. Grounding conductors shall be soft-drawn, stranded copper. Ground rods shall be driven into the earth so that after the installation is complete, the top of the ground rod will be approximately 300 mm below finished grade, except in handholes. Butt grounds shall not be used.

3.8.1 Ground Rods and Pole Butt Electrodes

The resistance to ground shall be measured using the fall-of-potential method described in IEEE Std 81. The maximum resistance of a driven ground rod shall not exceed 25 ohms under normally dry conditions. Whenever the required ground resistance is not met, additional electrodes shall be provided interconnected with grounding conductors, to achieve the specified ground resistance. The additional electrodes shall be up to three, 3 m long rods spaced a minimum of 3 m apart. Coupled and driven with the first rod. In high ground resistance, UL listed chemically charged ground rods may be used. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, the Contracting Officer shall be notified immediately. Connections below grade shall be fusion welded. Connections above grade shall be fusion welded or shall use UL 467 approved connectors.

3.8.2 Items to be Grounded

Ground conductors, metallic conduits, junction boxes, and noncurrent-carrying metallic parts of equipment shall be grounded. Connections above grade shall be made with solderless connectors, and those below grade shall be made by a fusion-welding process.

3.8.3 Lighting Pole

One ground rod shall be provided at each pole. Bases of metal or concrete lighting poles shall be connected to ground rods by means of No. 8 AWG bare copper wire. Lighting fixture brackets on wood and concrete poles shall be grounded to a No. 6 AWG bare copper grounding conductor connected to the ground rod.

3.8.4 Handhole

In each handhole, at a convenient point close to the wall, a ground rod shall be driven into the earth before the floor is poured, and approximately 100 mm of the ground rod shall extend above the floor after pouring. When precast concrete units are used, the top of the ground rod may be below the floor, and a No. 1/0 AWG copper ground conductor shall be brought inside through a watertight sleeve in the wall. Connection to ground rods shall be by means of bolted-clamp terminals or by an approved fusion-welding process. Ground wires shall be neatly and firmly attached to handhole walls, and the amount of exposed bare wire shall be held to a minimum.

3.8.5 Metal Cable Boxes

Metal cable boxes for direct-burial cable shall be connected to adjacent ground rods by wires with current-carrying capacities of at least 20 percent of the spliced phase conductors, but not less than No. 6 AWG.

3.9 TESTS

3.9.1 Operating Test

After the installation is completed and at such time as the Contracting Officer may direct, the Contractor shall conduct an operating test for approval. The equipment shall be demonstrated to operate in accordance with the requirements specified. The test shall be performed in the presence of the Contracting Officer. The Contractor shall furnish instruments and personnel required for the test, and the Government will furnish the necessary electric power.

3.9.2 Ground Resistance Measurements

The resistance to ground shall be measured by the fall-of-potential method described in IEEE Std 81.

The contractor shall maintain a separate set of drawings, elementary diagrams and wiring diagrams of the lighting to be used for "as-built" drawings. This set shall be accurately kept up to date by the Contractor with all changes and additions to the lighting system. In addition to being complete and accurate, this set of drawings shall be kept neat and shall not be used for installation purposes. Upon completion of the as-built drawings, a representative of the Government will review the as-built work with the Contractor. If the as-built work is not complete, the Contractor will be so advised and shall complete the work as required.

3.10 INSTALLATION

NOTE: Electrical designer shall coordinate these requirements with architectural plans and specifications. Lighting fixtures for facilities located in earthquake zones shall have additional supports and restraining devices as described in Army TI809-04, Seismic Design for Buildings.

Set lighting fixtures plumb, square, and level with ceiling and walls, in alignment with adjacent lighting fixtures, and secure in accordance with manufacturers' directions and approved drawings. Installation shall meet requirements of NFPA 70. Mounting heights specified or indicated shall be to the bottom of fixture for ceiling-mounted fixtures and to center of fixture for wall-mounted fixtures. Obtain approval of the exact mounting for lighting fixtures on the job before commencing installation and, where applicable, after coordinating with the type, style, and pattern of the ceiling being installed. Recessed and semi-recessed fixtures may be supported from suspended ceiling support system ceiling tees when the ceiling system support wires or rods are provided at a minimum of four wires or rods per fixture and located not more than 150 mm from each corner of each fixture. For recessed fixtures, provide support clips securely fastened to ceiling grid members, a minimum of one at or near each corner of each fixture. For round fixtures or fixtures smaller in size than the ceiling grid, provide a minimum of four wires or rods per fixture and locate at each corner.

3.11 FIELD QUALITY CONTROL

Upon completion of installation, conduct an operating test to show that equipment operates in accordance with requirements of this section.

FORM 1, ELECTRONIC BALLAST WARRANTY

1. Location ___________________________
2. Bldg. Name __________________
3. Bldg. No. _____
4. Installation Areas________________________________
5. Contract No. ____________________
6. Ballast Manufacturer Name/Address _____________________
7. Exchange Information __________________
8. Warranty Return Number: _________________________
9. Warranty Period: From _________ To __________
10. Acceptance Date: ____________
11. Inspector: __________________
12. Prime Contractor Name/Address: ______________________

Signature: _____________________________ Date: ________________

INSTRUCTIONS FOR FORM 1

1. Location: Name of activity as shown on contract.
2. Bldg. Name: As shown on contract or as provided by Contracting Officer.
3. Bldg. No.: As provided by Contracting Officer.
4. Installation Areas: Main areas in the building where ballasts are installed; floors, room numbers, lean-to, etc. A separate form is required for each ballast manufacturer used in the contract.
5. Contract No.: As shown on the contract.
6. Ballast Manufacturer Name/Address: Ballast manufacturer's name, address, and telephone number.
7. Exchange Information: Ballast exchange information such as point of contact, telephone number, shipping address if different from item 6, and any special shipping instructions.
8. Warranty Return Number: Return authorization number if required.
9. Warranty Period: Insert estimated start and end dates.
10. Acceptance Date: Show date ballasts were accepted by the Contracting Officer.
11. Inspector: Show Government inspector's name.
12. Prime Contractor Name/Address/Signature/Date: Shall be signed and dated by an official of the contracting firm.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 16 - ELECTRICAL

SECTION 16710

PREMISES DISTRIBUTION SYSTEM

04/97

-- End of Section Table of Contents --

SECTION 16710

PREMISES DISTRIBUTION SYSTEM
04/97

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

ANSI/TIA/EIA-568-B	(2001) Commercial Building Telecommunications Cabling Standard
ANSI/TIA/EIA-Draft 9	(August 24, 2001) Transmission Performance Specifications for 4-pair 100 ohm Category 6 Cabling
ANSI/TIA/EIA-569-A	(1998) Commercial Building Standard for Telecommunications Pathways and Spaces
ANSI/TIA/EIA-606	(1993) Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
ANSI/TIA/EIA-607	(1994) Commercial Building Grounding and Bonding Requirements for Telecommunications
TIA/EIA TSB 67	(1995) Transmission Performance Specifications for Field Testing of Unshielded Twisted-Pair Cabling Systems

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-80-576	(1994) Communications Wire and Cable for Wiring of Premises
ICEA S-83-596	(1994) Fiber Optic Premises Distribution Cable

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1999) National Electrical Code

1.2 SYSTEM DESCRIPTION

The premises distribution system shall consist of inside-plant horizontal, riser, and backbone cables and connecting hardware to transport telephone and data (including LAN) signals between equipment items in a building.

1.3 ENVIRONMENTAL REQUIREMENTS

Connecting hardware shall be rated for operation under ambient conditions of 0 to 60 degrees C and in the range of 0 to 95 percent relative humidity, noncondensing.

1.4 QUALIFICATIONS

1.4.1 Minimum Contractor Qualifications

All work under this section shall be performed by and all equipment shall be furnished and installed by a certified Telecommunications Contractor, hereafter referred to as the Contractor. The Contractor shall have the following qualifications in Telecommunications Systems installation:

a. Contractor shall have a minimum of 3 years experience in the application, installation and testing of the specified systems and equipment.

b. All supervisors and installers assigned to the installation of this system or any of its components shall have factory certification from each equipment manufacturer that they are qualified to install and test the provided products.

c. All installers assigned to the installation of this system or any of its components shall have a minimum of 3 years experience in the installation of the specified copper and fiber optic cable and components.

d. On-site supervisor shall be a Registered Communications Distribution Designer (RCDD).

1.4.2 Minimum Manufacturer Qualifications

The equipment and hardware provided under this contract will be from manufacturers that have a minimum of 3 years experience in producing the types of systems and equipment specified.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:
*8

SD-02 Shop Drawings

Premises Distribution System; G, RE~~AE~~

Detail drawings including a complete list of equipment and material. Detail drawings shall contain complete wiring and schematic diagrams and other details required to demonstrate that the system has been coordinated and will function properly as a system. Drawings shall include vertical riser diagrams, equipment rack details, elevation drawings of telecommunications closet walls, outlet face plate details for all outlet configurations, sizes and types of all cables, conduits, and cable trays. Drawings shall show proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work including clearance for maintenance and operation.

Record Drawings; G, RE

Record drawings for the installed wiring system infrastructure per ANSI/TIA/EIA-606. The drawings shall show the location of all cable terminations and location and routing of all backbone and horizontal cables. The identifier for each termination and cable shall appear on the drawings.

SD-03 Product Data

Record Keeping and Documentation; G, RE~~AE~~

Documentation on cables and termination hardware in accordance with ANSI/TIA/EIA-606.

Spare Parts; G, RE

Lists of spare parts, tools, and test equipment for each different item of material and equipment specified, after approval of detail drawings, not later than 2 months prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, and a list of spare parts recommended for stocking.

Manufacturer's Recommendations; G, RE~~AE~~

Where installation procedures, or any part thereof, are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations, prior to installation shall be provided. Installation of the item will not be allowed to proceed until the recommendations are received and approved.

Test Plan; G, RE

Test plan defining the tests required to ensure that the system meets technical, operational and performance specifications, 60 days prior to the proposed test date. The test plan must be approved before the start of any testing. The test plan shall identify the capabilities and functions to be tested, and include detailed instructions for the setup and execution of each test and procedures for evaluation and documentation of the results.

Qualifications; G, RE

The qualifications of the Manufacturer, Contractor, and the Installer to perform the work specified herein. This shall include proof of the minimum qualifications specified herein.

SD-06 Test Reports

Test Reports; G, RE

Test reports in booklet form with witness signatures verifying execution of tests. Test results will also be provided on 89 mm diskettes in ASCII format. Reports shall show the field tests performed to verify compliance with the specified performance criteria. Test reports shall include record of the physical parameters verified during testing. Test reports shall be submitted within 14 days after completion of testing.

SD-07 Certificates

Premises Distribution System; G, RE

Written certification that the premises distribution system complies with the ANSI/TIA/EIA-568-A, ANSI/TIA/EIA-569-A, and ANSI/TIA/EIA-606 standards.

Materials and Equipment; G, RE

Where materials or equipment are specified to conform, be constructed or tested to meet specific requirements, certification that the items provided conform to such requirements. Certification by a nationally recognized testing laboratory that a representative sample has been tested to meet the requirements, or a published catalog specification statement to the effect that the item meets the referenced standard, will be acceptable as evidence that the item conforms. Compliance with these requirements does not relieve the Contractor from compliance with other requirements of the specifications.

Installers; G, RE

The Contractor shall submit certification that all the installers are factory certified to install and test the provided products.

1.6 DELIVERY AND STORAGE

Equipment delivered and placed in storage shall be stored with protection from the weather, humidity and temperature variation, dirt and dust or other contaminants.

1.7 OPERATION AND MAINTENANCE MANUALS

Commercial off the shelf manuals shall be furnished for operation, installation, configuration, and maintenance for all products provided as a part of the premises distribution system. Specification sheets for all cable, connectors, and other equipment shall be provided.

1.8 RECORD KEEPING AND DOCUMENTATION

1.8.1 Cables

A record of all installed cable shall be provided on electronic media using Windows based computer cable management software per ANSI/TIA/EIA-606. The cable records shall include only the required data fields for each cable and complete end-to-end circuit report for each complete circuit from the assigned outlet to the entry facility per ANSI/TIA/EIA-606.

1.8.2 Termination Hardware

A record of all installed patch panels and outlets shall be provided on electronic media using Windows based computer cable management software per ANSI/TIA/EIA-606. The hardware records shall include only the required data fields per ANSI/TIA/EIA-606.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Materials and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products and shall be the manufacturer's latest standard design that has been in satisfactory use for at least 1 year prior to installation. Materials and equipment shall conform to the respective publications and other requirements specified below and to the applicable requirements of NFPA 70.

2.2 UNSHIELDED TWISTED PAIR CABLE SYSTEM

2.2.1 Backbone Cable

Backbone cable shall meet the requirements of ICEA S-80-576 and ANSI/TIA/EIA-568-A for Category 3 100-ohm unshielded twisted pair cable. Cable shall be label-verified. Cable jacket shall be factory marked at regular intervals indicating verifying organization and performance level. Conductors shall be solid untinned copper 24 AWG. Cable shall be rated CMP per NFPA 70.

2.2.2 Horizontal Cable

Horizontal cable shall meet the most recent requirements of ANSI/TIA/EIA-568-A for Category 6. Cable shall be label-verified. Cable jacket shall be factory marked at regular intervals indicating verifying organization and performance level. Cable shall be rated CMP per NFPA 70.

2.2.3 Connecting Hardware

Connecting and cross-connecting hardware shall be the same category as the cable it serves. Hardware shall be in accordance with ANSI/TIA/EIA-568-A.

2.2.3.1 Telecommunications Outlets

Wall and desk outlet plates shall come equipped with one telephone jack and two data modular jacks, with the top jack labeled "voice" and the bottom jacks labeled "data. Modular jacks shall be the same category as the cable they terminate and shall meet the requirements of ANSI/TIA/EIA-568-A. Modular jack pin/pair configuration shall be T568A per ANSI/TIA/EIA-568-A. Modular jacks shall be unkeyed. Faceplates shall be provided and shall be ivory in color, impact resistant plastic. Mounting plates shall be provided for system furniture and shall match the system furniture in color. Outlet assemblies used in the premises distribution system shall consist of modular jacks assembled into both simplex and duplex outlet assemblies in single or double gang covers as indicated on the drawings. The modular jacks shall conform to the requirements of ANSI/TIA/EIA-568-A, and shall be rated for use with Category 6 cable in accordance with ANSI/TIA/EIA-568-A and shall meet the Link Test parameters as listed in TIA/EIA TSB 67 and supplemented by ANSI/TIA/EIA-568-A-5.

2.2.3.2 Patch Panels

Patch panels shall consist of eight-position modular jacks, with rear mounted type 110 insulation displacement connectors, arranged in rows or columns on 480 mm rack mounted panels. Jack pin/pair configuration shall be T568A per ANSI/TIA/EIA-568-A. Jacks shall be unkeyed. Panels shall be labeled with alphanumeric x-y coordinates. The modular jacks shall conform to the requirements of ANSI/TIA/EIA-568-A, and shall be rated for use with Category 6 cable in accordance with ANSI/TIA/EIA-568-A and shall meet the Link Test parameters as listed in TIA/EIA TSB 67.

2.2.3.3 Patch Cords

Patch cords shall be cable assemblies consisting of flexible, twisted pair stranded wire with eight-position plugs at each end. Cable shall be label-verified. Cable jacket shall be factory marked at regular intervals indicating verifying organization and performance level. Patch cords shall be wired straight through; pin numbers shall be identical at each end and shall be paired to match T568A patch panel jack wiring per ANSI/TIA/EIA-568-A. Patch cords shall be unkeyed. Patch cords shall be factory assembled. Patch cords shall conform to the most recent requirements of ANSI/TIA/EIA-568-A for Category 6 and GigE performance and IEEE 802.3ab specifications.

2.2.3.4 Terminal Blocks

Terminal blocks shall be wall mounted wire termination units consisting of insulation displacement connectors mounted in plastic blocks, frames or housings. Blocks shall be type 110 which meet the requirements of ANSI/TIA/EIA-568-A, and shall be rated for use with Category 6 cable in accordance with ANSI/TIA/EIA-568-A-5 and shall meet the Link Test parameters as listed in TIA/EIA TSB 67 and supplemented by ANSI/TIA/EIA-568-A-5. Blocks shall be mounted on standoffs and shall include cable management hardware. Insulation displacement connectors shall terminate 22 or 24 gauge solid copper wire as a minimum, and shall be connected in pairs so that horizontal cable and connected jumper wires are on separate connected terminals.

2.3 FIBER OPTIC CABLE SYSTEM

2.3.1 Backbone Cable

2.3.1.1 Singlemode

Singlemode fiber optic backbone cable shall meet the requirements of Insulated Cable Engineers Association ICEA S-80-596, RUS Bulletin 1753F-601, EIA 472D standards and the following: operation at a center wavelength of 1310 and 1550 m; core/cladding diameter 8.3 nominal/125 micrometer; maximum attenuation .5 dB/km at 1310 nm, .5 dB/km at 1550 nm. Numerical aperture for each fiber shall be a minimum of 0.10. Cable construction shall be tight buffered type. Cable shall be imprinted with fiber count and aggregate length at regular intervals. Individual fibers shall be color coded for identification. Cable shall be rated OFNP per NFPA 70.

2.3.2 Connecting Hardware

2.3.2.1 Connectors

Connectors shall be SC type with ceramic ferrule material with a maximum insertion loss of .5 dB. Connectors shall meet performance requirements of ANSI/TIA/EIA-568-A. Connectors shall be field installable. Connectors shall utilize adhesive for fiber attachment to ferrule. Connectors shall terminate fiber sizes as required for the service.

2.3.2.2 Patch Panels

Patch panels shall be a complete system of components by a single manufacturer, and shall provide termination, splice storage, routing, radius limiting, cable fastening, storage, and cross-connection. Patch panels shall be (480 mm) rack mounted panels. Patch panels shall provide strain relief for cables. Panels shall be provided with labeling space. Patch panel connectors and couplers shall be the same type and configuration as used elsewhere in the system.

2.3.2.3 Patch Cords

Patch cords shall be cable assemblies consisting of flexible optical fiber cable with connectors of the same type as used elsewhere in the system. Optical fiber shall be the same type as used elsewhere in the system. Patch cords shall be complete assemblies from manufacturer's standard product lines.

2.4 EQUIPMENT RACKS

2.4.1 Floor Mounted Open Frame

Floor mounted equipment racks shall be welded steel relay racks with uprights to mount equipment 480 mm wide. Uprights shall be 75 mm deep channel, 32 mm wide, drilled and tapped 12-24 in a 13 mm pattern. Racks shall be provided with a standard top crossmember, and predrilled base plate to allow floor fastening. Open frame equipment racks shall be 2.1 m in height and painted. AC outlets shall be provided as shown.

2.4.2 Wall Mounted Open Frame

Wall mounted open frame equipment racks shall be steel relay racks to mount equipment 480 mm wide with standoff brackets for wall mounting. Uprights shall be drilled and tapped 12-24 in a 13 mm pattern. Standoff brackets shall be of sufficient length for a 150mm clearance between rack and wall. Wall mounted open frame racks shall be hinged. AC outlets shall be provided as shown.

2.4.3 Cable Guides

Cable guides shall be specifically manufactured for the purpose of routing cables, wires and patch cords horizontally and vertically on 480 mm equipment racks. Cable guides shall consist of ring or bracket-like devices mounted on rack panels for horizontal use or individually mounted for vertical use. Cable guides shall mount to racks by screws and/or nuts and lockwashers.

2.5 EQUIPMENT MOUNTING BACKBOARD

Plywood backboards shall be provided, sized as shown, painted with white or light colored fire retardant paint.

2.6 TELECOMMUNICATIONS OUTLET BOXES

Electrical boxes for telecommunication outlets shall be 117 mm square by 53 mm deep with minimum 9 mm deep single gang plaster ring as shown. Provide a minimum 25 mm conduit.

PART 3 EXECUTION

3.1 INSTALLATION

System components and appurtenances shall be installed in accordance with NFPA 70, manufacturer's instructions and as shown. Necessary interconnections, services, and adjustments required for a complete and operable signal distribution system shall be provided. Components shall be labeled in accordance with ANSI/TIA/EIA-606. Penetrations in fire-rated construction shall be firestopped in accordance with Section 07840 FIRESTOPPING. Conduits, outlets and raceways shall be installed in accordance with Section 16415 ELECTRICAL WORK, INTERIOR. Wiring shall be installed in accordance with ANSI/TIA/EIA-568-A and as specified in Section 16415 ELECTRICAL WORK, INTERIOR. Wiring, and terminal blocks and outlets shall be marked in accordance with ANSI/TIA/EIA-606. Cables shall not be installed in the same cable tray, utility pole compartment, or floor trench compartment with ac power cables. Cables not installed in conduit or wireways shall be properly secured and neat in appearance and, if installed in plenums or other spaces used for environmental air, shall comply with NFPA 70 requirements for this type of installation.

3.1.1 Horizontal Distribution Cable

The rated cable pulling tension shall not be exceeded. Cable shall not be stressed such that twisting, stretching or kinking occurs. Cable shall not be spliced. Fiber optic cables shall be installed either in conduit or through type cable trays to prevent microbending losses. Copper cable not in a wireway shall be suspended a minimum of 200 mm above ceilings by cable supports no greater than 1.5 m apart. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items. Placement of cable parallel to power conductors shall be avoided, if possible; a minimum separation of 300 mm shall be maintained when such placement cannot be avoided. Cables shall be terminated; no cable shall contain unterminated elements. Minimum bending radius shall not be exceeded during installation or once installed. Cable ties shall not be excessively tightened such that the transmission characteristics of the cable are altered. In raised floor areas, cable shall be installed after the flooring system has been installed. Cable 1.8 meters long shall be neatly coiled not less than 300 mm in diameter below each feed point in raised floor areas.

3.1.2 Riser and Backbone Cable

Vertical cable support intervals shall be in accordance with manufacturer's recommendations. Cable bend radius shall not be less than ten times the outside diameter of the cable during installation and once installed. Maximum tensile strength rating of the cable shall not be exceeded. Cable shall not be spliced.

3.1.3 Telecommunications Outlets

3.1.3.1 Faceplates

As a minimum each jack shall be labeled as to its function and a unique number to identify cable link.

3.1.3.2 Cables

Unshielded twisted pair and fiber optic cables shall have a minimum of 150 mm of slack cable loosely coiled into the telecommunications outlet boxes. Minimum manufacturers bend radius for each type of cable shall not be exceeded.

3.1.3.3 Pull Cords

Pull cords shall be installed in all conduit serving telecommunications outlets which do not initially have fiber optic cable installed. Conduits shall be sized for future growth of a minimum of two (2) strands of fiber optic cable.

3.1.4 Terminal Blocks

Terminal blocks shall be mounted in orderly rows and columns. Adequate vertical and horizontal wire routing areas shall be provided between groups of blocks. Industry standard wire routing guides shall be utilized.

3.1.5 Unshielded Twisted Pair Patch Panels

Patch panels shall be mounted in equipment racks with sufficient modular jacks to accommodate the installed cable plant plus 10 percent spares. Cable guides shall be provided above, below and between each panel.

3.1.6 Fiber Optic Patch Panels

Patch panels shall be mounted in equipment racks with sufficient ports to accommodate the installed cable plant plus 10 percent spares. A slack loop of fiber shall be provided within each panel. Loop shall be 900 mm in length. The outer jacket of each cable entering a patch panel shall be secured to the panel to prevent movement of the fibers within the panel, using clamps or brackets specifically manufactured for that purpose.

3.1.7 Equipment Racks

Open frame equipment racks shall be bolted to the floor. Cable guides shall be bolted or screwed to racks. Racks shall be installed level. Ganged racks shall be bolted together. Ganged rack cabinets shall have adjacent side panels removed. Wall mounted racks shall be secured to the mounting surface to prevent fully loaded racks from separating from the mounting surface.

3.1.8 Rack Mounted Equipment

Equipment to be rack mounted shall be securely fastened to racks by means of the manufacturer's recommended fasteners.

3.2 TERMINATION

Cables and conductors shall sweep into termination areas; cables and conductors shall not bend at right angles. Manufacturer's minimum bending radius shall not be exceeded. When there are multiple system type drops to individual workstations, relative position for each system shall be maintained on each system termination block or patch panel.

3.2.1 Unshielded Twisted Pair Cable

Each pair shall be terminated on appropriate outlets, terminal blocks or patch panels. No cable shall be unterminated or contain unterminated elements. Pairs shall remain twisted together to within the proper distance from the termination as specified in ANSI/TIA/EIA-568-A. Conductors shall not be damaged when removing insulation. Wire insulation shall not be damaged when removing outer jacket.

3.2.2 Fiber Optic Cable

Each fiber shall have connectors installed. The pull strength between the connector and the attached fiber shall be not less than 11.3 kg. The mated pair loss, without rotational optimization, shall not exceed 1.0 dB. Fiber optic connectors shall be installed per ANSI/TIA/EIA-568-A.

3.3 GROUNDING

Signal distribution system ground shall be installed in the telecommunications entrance facility and in each telecommunications closet in accordance with ANSI/TIA/EIA-607 and Section 16415 ELECTRICAL WORK, INTERIOR. Equipment racks shall be connected to the electrical safety ground.

3.4 ADDITIONAL MATERIALS

The Contractor shall provide the following additional materials required for facility startup.

a. 10 of each type outlet.

b. 10 of each type cover plate.

c. 1 of each type terminal block for each telecommunications closet.

d. 4 Patch cords of 3 m for each telecommunications closet.

e. 1 Set of any and all special tools required to establish a cross connect and to change and/or maintain a terminal block.

3.5 ADMINISTRATION AND LABELING

3.5.1 Labeling

3.5.1.1 Labels

All labels shall be in accordance with ANSI/TIA/EIA-606.

3.5.1.2 Cable

All cables will be labeled using color labels on both ends with encoded identifiers per ANSI/TIA/EIA-606.

3.5.1.3 Termination Hardware

All workstation outlets and patch panel connections will be labeled using color coded labels with encoded identifiers per ANSI/TIA/EIA-606.

3.6 TESTING

Materials and documentation to be furnished under this specification are subject to inspections and tests. All components shall be terminated prior to testing. Equipment and systems will not be accepted until the required inspections and tests have been made, demonstrating that the signal distribution system conforms to the specified requirements, and that the required equipment, systems, and documentation have been provided.

3.6.1   Unshielded Twisted Pair Tests

All metallic cable pairs shall be tested for proper identification and continuity. All opens, shorts, crosses, grounds, and reversals shall be corrected. Correct color coding and termination of each pair shall be verified in the communications closet and at the outlet. Horizontal wiring shall be tested from and including the termination device in the communications closet to and including the modular jack in each room. Backbone wiring shall be tested end-to-end, including termination devices, from terminal block to terminal block, in the respective communications closets. These test shall be completed and all errors corrected before any other tests are started.

3.6.2   Category 6 Circuits

All category 6 circuits shall be tested using a test set that meets the Class II accuracy requirements of TIA/EIA TSB 67 standard, including the most recent additional tests and test set accuracy requirements of ANSI/TIA/EIA-568-A. Testing shall use the Basic Link Test procedure of TIA/EIA TSB 67, as supplemented by ANSI/TIA/EIA-568-A. Cables and connecting hardware which contain failed circuits shall be replaced and retested to verify the standard is met.

3.6.3   Fiber Optic Cable

Unless stated otherwise, tests shall be performed from both ends of each circuit. Connectors shall be visually inspected for scratches, pits or chips and shall be reterminated if any of these conditions exist. Each circuit leg and complete circuit shall be tested for insertion loss at 850 and 1300 1310 and 1550 nm using a light source similar to that used for the intended communications equipment. High-resolution optical time domain reflectometer (OTDR) tests shall be performed from one end of each fiber. Scale of the OTDR trace shall be such that the entire circuit appears over a minimum of 80 percent of the X-axis.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 16 - ELECTRICAL

SECTION 16770A

PUBLIC ADDRESS SYSTEMS

07/89

-- End of Section Table of Contents --

SECTION 16770A

PUBLIC ADDRESS SYSTEMS
07/89

PART 1   GENERAL

1.1   REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

EIA ANSI/EIA/310-D	(1992) Cabinets, Racks, Panels, and Associated Equipment

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(1999) National Electrical Code

1.2   SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:
*8

SD-02 Shop Drawings

Radio and Public Address System; G, RE~~AE~~

Detail drawings consisting of a complete list of equipment and material, including manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts, and installation instructions. Detail drawings shall also contain complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Drawings shall show proposed layout of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation.

Detail drawings consisting of a complete list of equipment and material, including manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts, and installation instructions. Detail drawings shall also contain complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Drawings shall show proposed layout of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation.

SD-03 Product Data

Spare Parts~~; G, AE~~

Spare parts data for each different item of material and equipment specified, after approval of the detail drawings and not later than one month prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with current unit prices and source of supply.

SD-06 Test Reports

Approved Test Procedures; G, RE

Test plan and test procedures for the acceptance tests. The test plan and test procedures shall explain in detail, step-by-step actions and expected results to demonstrate compliance with the requirements specified. The procedure shall also explain methods for simulating the necessary conditions of operation to demonstrate system performance.

Acceptance Tests; G, RE

Test reports in booklet form showing all field tests performed to adjust each component and to prove compliance with the specified performance criteria, upon completion and testing of the installed system. The reports shall include the manufacturer, model number, and serial number of test equipment used in each test. Each report shall indicate the final position of controls and operating mode of the system.

SD-10 Operation and Maintenance Data

Radio and Public Address System; G, RE

Six copies of the operation manual outlining the step-by-step procedures required for system start up, operation, and shutdown. The manual shall include equipment layout and schematics of simplified wiring and control diagrams of the system as installed, the manufacturer's name, model number, and brief description of all equipment and their basic operating features. Six copies of maintenance manual listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. The manual shall include equipment layout and schematics and simplified wiring and control diagrams of the system.

1.3 SYSTEM DESCRIPTION

The public address system shall consist of an audio distribution network to include amplifiers, mixers, speakers, cabling, and any ancillary components required to meet the required system configuration and operation.

1.3.1 Multi-Channel System with Paging

The system shall include inputs for telephone, program sources, single channel paging, control for each input, power amplifying equipment, and accessories required to output the public address and paging audio signals through selected portions of the audio distribution network as indicated.

1.3.2 System Performance

The system shall provide even sound distribution throughout the designated area, plus or minus 3 dB for the 1-octave band centered at 4000 Hz. The system shall provide uniform frequency response throughout the designated area, plus or minus 3 dB as measured with 1/3-octave bands of pink noise at locations across the designated area selected by the Contracting Officer. The system shall be capable of delivering 75 dB average program level with additional 10 dB peaking margin sound pressure level (SPL) to any location in the area at an acoustic distortion level below 5 percent total harmonic distortion (THD). Unless otherwise specified the sound pressure reference level is 20 micro Pascal (0.00002 Newtons per square meter).

1.4 DELIVERY AND STORAGE

Equipment placed in storage until installation time shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, and other contaminants.

1.5 VERIFICATION OF DIMENSIONS

The Contractor shall become familiar with the details of the work and working conditions, shall verify dimensions in the field, and shall advise the Contracting Officer of any discrepancies before performing the work.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Material and equipment to be provided shall be the standard products of a manufacturer regularly engaged in the manufacture of such products, and shall essentially duplicate material and equipment that have been in satisfactory use at least 2 years. All components used in the system shall be commercial designs that comply with the requirements specified. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.1.1 Identical Items

Items of the same classification shall be identical. This requirement includes equipment, modules, assemblies, parts, and components.

2.1.2 Nameplates

Each major component of equipment shall have the manufacturer's name, address, model and catalog number, and serial number on a plate secured to the equipment.

2.2 MIXER AMPLIFIER

Mixer amplifier shall as a minimum conform to the following specifications:

Rated Power Output:	120 watts RMS
Frequency Response:	Plus or Minus 2 dB, 60-13,000 Hz
Distortion:	Less than 1 percent at RPO, 60 - 13,000 Hz

Inputs:	2 Aux. (high-impedance)
Output Impedance:	Balanced 4, 8, and 16 ohms
Output Voltage:	25 and 70 volts
Power Requirement:	110-125 Vac 60 Hz

2.3 LOUDSPEAKERS

2.3.1 Cone Speaker

The cone speaker shall as a minimum conform to the following specifications:

Application:	Ceiling
Frequency range:	60 to 12,000 Hz
Power Rating:	Normal - 7 watts Peak - 10 watts
Voice Coil Impedance:	8 ohms
Line Matching Transformer Type:	25/70 volt line
Capacity:	2 watts
Magnet:	8 ounces or greater
Primary Taps:	0.5, 1, and 2 watts
Primary Impedance:	25 volts - 1250, 625, and 312 ohms 70 volts - 10k, 5k, and 2.5k ohms
Frequency Response:	30 - 20,000 Hz
Insertion Loss:	Less than 1 dB

2.3.2 Horn Speaker

The horn speaker shall as a minimum conform to the following specifications:

Application:	Indoor
Frequency Response:	400 - 14,000 Hz
Power Taps:	70 volt line - .9, 1.8, 3.8, 7.5, and 15 watts
Impedance:	5000, 2500, 1300, 670, 330, 90, and 45 ohms
Power Rating:	Normal - 7 watts Peak - 15 watts

2.4 SPEAKER SWITCHING PANEL

Zone control shall be provided for the paging function. The speaker switching panel shall contain at least 12 double-pole, 3-position lever-type selector switches with mechanical detents and shall be rack-mounted. A designation strip shall be provided. Power supply shall be provided for priority relays and controls, rack-mounted and sized for a capacity equal to 200 percent of the as-built control system, and shall operate at 24 Vdc. Input and output shall be protected to permit Class 2 wiring in accordance with NFPA 70.

2.5 PRIORITY RELAYS AND CONTROLS

Priority relays and controls required to accomplish operations specified shall be provided. Relays shall be completely enclosed with a plastic dust cover for maximum protection against foreign matter, and shall be plug-in type. Relays shall be provided with a diode wired across the relay coil for transient suppression and shall be installed utilizing factory-prewired, rack-mounted receptacle strips. Coil shall be maximum 24 volts dc.

2.6 SWITCHES AND CONTROLS

2.6.1 Remote Loudspeaker Volume Controls

Remote volume controls shall be an auto transformer type with detented 3 dB steps and an OFF position. The controls shall be wall-mounted in single-gang outlet boxes and furnished with engraved switching plates finished to match approved finish of electrical wall switches. Insertion loss of the controls shall not exceed 0.6 dB and the power-handling capacities of the control shall be 10 watts. Low-voltage priority override relays shall be furnished as part of these controls with all wiring to the racks to allow override of the volume controls for priority announcements.

2.7 EQUIPMENT RACKS

Equipment shall be mounted on 482.6 mm (19 inch) racks in accordance with EIA ANSI/EIA/310-D and located as shown on drawings. Ventilated rear panels, solid side panels, and solid top panels shall be provided. Perforations or louvers may be provided in front panels to ensure adequate ventilation of equipment. The racks and panels shall be factory finished with a uniform baked enamel over rust inhibiting primer.

2.8 SPEAKER CABLE

Cables shall be of the gauge required depending upon the cable run length. In no case shall any cable be used which is smaller than 20 AWG. Insulation on the conductors shall be polyvinyl chloride (PVC) or an equivalent synthetic thermoplastic not less than 0.2 mm. Cables shall be shielded with a 34-gauge tinned soft copper strand formed into a braid. Cables shall be jacketed with a PVC compound. The jacket thickness shall be 0.5 mm minimum.

2.9 POWER SURGE PROTECTION

Major components of the system such as power amplifiers, shall have a device, whether internal or external, which provides protection against voltage spikes and current surges originating from commercial power sources.

2.10 SIGNAL SURGE PROTECTION

Major components of the system shall have internal protection circuits which protects the component from mismatched loads, direct current, and shorted output lines.

PART 3 EXECUTION

3.1 INSTALLATION

All equipment shall be installed as indicated and specified, and in accordance with the manufacturer's recommendations except where otherwise indicated. Equipment mounted out-of-doors or subject to inclement conditions shall be weatherproofed.

3.1.1 Equipment Racks

Racks shall be mounted side-by-side and bolted together. Items of the same function shall be grouped together, either vertically or side-by-side. Controls shall be symmetrically arranged at a height as shown. Audio input and interconnections shall be made with approved shielded cable and plug connectors; output connections may be screw terminal type. All connections to power supplies shall utilize standard male plug and female receptacle connectors with the female receptacle being the source side of the connection. Inputs, outputs, interconnections, test points, and relays shall be accessible at the rear of the equipment rack for maintenance and testing. Each item shall be removable from the rack without disturbing other items or connections. Empty space in equipment racks shall be covered by blank panels so that the entire front of the rack is occupied by panels.

3.1.2 Wiring

Wiring shall be installed in rigid conduit, intermediate metal conduit, cable trays, or electric metallic tubing as specified in Section 16415 ELECTRICAL WORK, INTERIOR. Wiring for microphone, grounding, line level, video, speaker and power cables shall be isolated from each other by physical isolation and metallical shielding. Shielding shall be terminated at only one end.

3.2 GROUNDING

All grounding practices shall comply with NFPA 70. The antenna mast shall be separately grounded. The system shall utilize a multiple-point signal grounding scheme where conductive path connections are required between each piece of equipment and the reference ground point. An isolated ground bar for power shall be provided for the connection of the main system components. The ground bar shall be connected to the main service ground utilizing a No. 6 conductor.

3.3 ACCEPTANCE TESTS

After installation has been completed, the Contractor shall conduct acceptance tests, utilizing the approved test procedures, to demonstrate that equipment operates in accordance with specification requirements. The Contractor shall notify the Contracting Officer 30 days prior to the performance of tests. In no case shall notice be given until after the Contractor has received written Contracting Officer approval of the test plans as specified. The acceptance tests shall include originating and receiving messages at specified stations, at proper volume levels, without cross talk or noise from other links or nondesignated units.

3.4 TRAINING

The Contractor shall conduct a training course for 4 members of the operating and maintenance staff as designated by the Contracting Officer. The training course will be given at the installation during normal working hours for a total of 40 hours and shall start after the system is functionally complete but prior to final acceptance tests. The field instructions shall cover all of the items contained in the approved operating and maintenance manuals, as well as demonstrations of routine maintenance operations. The Contracting Officer shall be notified at least 14 days prior to the start of the training course.

-- End of Section --

SECTION 16850

HEAT TRACING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Requirements of Division 16 Sections apply to this Section.

1.2 SUMMARY

A. This Section includes heat tracing for piping and systems subject to freezing, and associated equipment.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When usd, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:
*8
SD-02 Shop Drawings

All Equipment~~; G, AE~~

Shop drawings for all equipment, Include dimensioned plans, sections, and elevations. Show minimum clearances, installed devices, major features, and materials lists. Include the following:

Nameplate legends.

Connection diagrams.

Operational and maintenance instructions.

SD-03 Product Data

Each Product and Component~~; G, AE~~

Product data for each product and component specified.

SD-06 Test Reports

Field Test; G, RE

Report of field tests and observations certified by the testing organization.

SD-10 Operation and Maintenance Data

Materials and Product Data; G, RE

Maintenance data for materials and products, for inclusion in Operating and Maintenance Manual specified in Division 1 and in Division 16 Section "Basic Electrical Requirements."

1.4 QUALITY ASSURANCE

A. Listing and Labeling: Provide heat tracing equipment that is listed and labeled.

1. The terms "listed" and "labeled" shall be as defined in the National Electrical Code, Article 100.

2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

B. Manufacturer's Qualifications: Manufacturer shall be regularly engaged in manufacturing heat tracing systems complying with the requirements of these Specifications, and experienced with at least 5 projects of similar size and scope.

C. Field-Testing Organization Qualifications: To qualify for acceptance, a testing organization must demonstrate, based on evaluation of organization-submitted criteria conforming to ASTM E 699, that it has the experience and capability to conduct satisfactorily the testing indicated.

D. Electrical Component Standard: Components and installation shall comply with NFPA 70, "National Electrical Code."

E. National Electrical Manufacturers Association (NEMA):

F. Underwriters Laboratories (UL):

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store so condensation will not form on or in equipment.

B. Handle equipment in accordance with manufacturer's instructions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements.

2.2 DESCRIPTION

A. Heat Trace Cable

1. The electric heat trace cable shall be parallel resistance, self regulating type. The cable shall have a minimum impact resistance of 20 foot - pounds and be able to withstand long periods under wet insulation without shorting.

2. Cable shall have a maximum diameter of .255 inches and be capable of overlapping itself for installation on pipe valves, drains, etc.

3. Cable shall employ a tinned copper braid and the outer jacket of cable to allow for proper electrical grounding and personnel protection.

4. Heating cable shall be tested for jacket moisture integrity and be 100 percent tested for rated heat output.

5. Heating cable watts/foot ratings and voltages are as specified on drawings.

B. Heat Trace Controller

1. Heat trace controller shall be a thermostat with pipe sensing bulb.

2. Thermostat shall have a 0E - 150EF temperature range with a $\pm$ 5EF tolerance.

3. The maximum bulb temperature shall be 200EF.

4. Thermostat switch rating shall be 25 amps at 120-250 VAC.

5. Thermostat shall have a 6 ft.-0" minimum length capillary lead, with a flexible protective sleeve over lead.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Heating Cable

1. All heating cable shall be stored in their original shipping container or on reels until they are ready to install.

2. All cables shall be tested electrically in field to assure that there has been no damage to cable during shipment.

3. Cables shall be secured to pipe by means of a non-metallic fiberglass adhesive tape, every 12".

4. Cables shall be spiraled around pipes to achieve the watts/foot required and as indicated on drawings.

5. Install additional cable at all heat sinks (i.e., valves and drains).

6. Cables shall be run a minimum of 3 ft-0" into heated areas.

B. Thermostat

1. Install thermostat on interior of wall as close to pipe as possible.

3.2 FIELD QUALITY CONTROL

A. General: Comply with inspection and testing standards listed herein.

B. Testing: Perform the following tests on the completed, installed, heat tracing system:

1. Circuit continuity.

2. Controller/thermostat operation.

3. Measurement of heat/BTU output in accordance with manufacturer's specifications.

4. Any other tests recommended by the manufacturer.

END OF SECTION 16850

SECTION 16991

COMMISSIONING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of Contract including General and Supplemental Conditions and Division 1 Specification sections apply to this section.

B. The requirements of Division 16 apply to this section.

1.2 SUMMARY

A. This section will apply to all electrical equipment, describing testing and acceptance procedures, preparation and final sign-off before acceptance by the COE.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Commissioning Team; G, RE

List of team members who will represent the Contractor in the pre-commissioning checks and functional performance testing, at least 2 weeks prior to the start of pre-commissioning checks. Proposed revision to the list, prior to the start of the impacted work.

Test Procedures; G, RE

Detailed procedures for pre-commissioning checks and functional performance tests, at least 4 weeks prior to the start of pre-commissioning checks.

Test Schedule; G, RE

Schedule for pre-commissioning checks and functional performance tests, at least 2 weeks prior to the start of pre-commissioning checks.

SD-06 Test Reports

Test Reports; G, RE

Completed pre-commissioning checklists and functional performance test checklists organized by system and by subsystem and submitted as one package. The results of failed tests shall be included along with a description of the corrective action taken.

Contractor shall submit all procedures, checklists, and scope description of the work to be done commissioning the systems. This description will be submitted in a bond form containing, but not limited to the following:

1. Description of experience doing this type of work.

2. List of equipment to be commissioned.

3. Commissioning plan/procedures.

4. Training plan for Fort Gillem personnel.

1.4 RESPONSIBILITIES

A. The electrical contractor will be responsible for providing labor, material, equipment, etc., required within the scope of this specialty to facilitate the commissioning process. The electrical contractor will perform tests and verification procedures required by the commissioning process when requested by the COE.

NOTE: It is essential that these requirements be included in each of the applicable specification sections in order that a binding requirement is on each contractor.

B. Contracting Officer

1. COE will schedule personnel to participate in electrical commissioning process.

NOTE: This may include building security personnel, building engineer, electrical operation and maintenance personnel. Personnel operating and maintaining equipment and systems will attend training sessions, factory schools, and educational institutions where indicated.

1.5 QUALITY ASSURANCE

A. Qualifications:

1. Commissioning will be reviewed by Fort Gillem and the COE.

2. The contractor shall follow all issued standards and have reviewed and be versed with the requirements for this project.

3. The contractor implementing the commissioning process shall have submitted resumes and experience exhibiting knowledge of the process with pressure projects of the magnitude and complexity of this project.

1.6 DOCUMENTATION

A. Contractor shall obtain all specifications, shop drawings, test reports, drawings, etc., to perform work.

B. Contractor shall be responsible that all sign-offs have been performed and latest information is utilized for testing.

PART 2 PRODUCTS

2.1 Not Used

PART 3 EXECUTION

3.01 COMMISSIONING OF EQUIPMENT AND SYSTEMS

A. Comprehensive Work Plan

1. Provide detailed, methodical, schedule start up, and commissioning procedures and execution of same for every system and piece of equipment provide under this section.

2. Attend start up and commissioning meetings on a regular basis and as directed by the COE.

3. Develop and provide a written start up plan for this work and submit to the COE within 3 months of the contract award. Assist in the development of an integrated start up plan and schedule. The plan and schedule shall identify tasks, start and complete dates, critical path items, interface requirements with other trades and major equipment start up, as minimum requirements of the plan.

4. Develop and submit for approval a specific start up check out and sign off form for each and every system.

5. Develop and submit for approval a specific start up check out and sign off form for every piece of major equipment as well as other equipment hereafter listed.

6. Refer to the generic example start up and check out form for systems and equipment as hereinafter included.

7. Execute the final approved start up and commissioning plan.

8. The COE may check the completed installation either sequentially as different parts are completed, or when the entire installation is complete, at the sole option of the COE.

9. This contractor shall arrange that the COE in addition to other test witnesses that may be specified, shall witness the required tests. At the conclusion of each such test this contractor shall

submit a letter and enclosed commissioning forms signed by the COE stating that:

a. he is the COE,

b. he has personally witnessed the test (give the name of the test),

c. the date of testing,

d. the results of testing, as compared to specified performance, listing the name, title, and company affiliation of all those witnessing the test.

B. Provide qualified personnel, equipment, apparatus and services for start-up and testing of electrical systems, to performance data shown in schedules, as specified for commissioning forms and as required by codes, standards, regulations and authorities having jurisdiction including City Inspectors, Owners and COE.

C. Before testing begins, a meeting shall be held by COE with the electrical contractor. All personnel shall at least include the actual workmen that will perform the tasks. The electrical contractor shall present the COE with the pre-completed commissioning forms. Allow one full day for this meeting.

D. Do not cover or conceal work before testing and inspection and obtaining approval.

E. Damage and defects discovered or resulting from startup and testing shall be repaired or replaced by this contract to like-new condition with acceptable materials. Tests shall be continued until system operates without adjustments or repairs.

F. For each piece of equipment, copy nameplate data and include in report.

G. Submit six copies of commissioning reports to the COE.

H. Provide capacity and performance of equipment by field testing. Install equipment and instruments required for testing.

I. Qualified representative of equipment manufacturer shall be present at test.

J. Start up and testing procedures outlined hereinafter are the minimum effort required for the project. Contractor shall use any additional procedures he feels will be necessary to properly startup and test the job at no additional cost to Owner.

K. Systems and Equipment Requiring Commissioning.

1. Commission the following systems and equipment in strict accordance with the attached forms identified for each system and each

piece of equipment (plus any changes during construction).

a. Systems

1) Raceway System
2) Conductor System and Wiring Devices
3) Grounding System
4) Lighting Control System
5) Occupancy Sensors
6) Heat Trace

b. Equipment (Provide Manufacturers representative and follow manufacturers start-up procedure).

1) Switchboards
2) Panelboards
3) Dry-type Transformers
4) UPS System
5) Motors
6) Variable Frequency Drives
7) Lighting Control
8) Packaged Generator and Transfer Switches

ELECTRICAL START-UP AND CHECK OUT FORM		
1.a	Raceway System: Check Conduits and Boxes Rigidly and Adequately Supported	
Conduit/Box Tag Number	**Date**	**Performed By**
List Each Conduit/Box Checked)		(Name of Actual Checker)

ELECTRICAL START-UP AND CHECK OUT FORM

SYSTEM	DATE PERFORMED	SIGN-OFFS ELEC.	SIGN-OFFS GC
1. Raceway System Check: a. Conduits and boxes rigidly and adequately supported. b. Conduit connections made up tight. c. Liquid-tight flexible conduit jacket ends adequately sealed. d. Covers on conduits, junction boxes and raceways secured with all fastening devices and fitted and gaskets where required. e. All unused conduit openings plugged f. Conduit seals properly located in accordance with NEC. g. Cable trays rigidly and adequately supported. h. Cable trays - tightness of splice plates. i. Cable trays grounded j. All raceway openings in walls sealed. k. All raceway fire seals installed l. Pull lines installed in all empty raceways.			
2. Conductor System and Wiring Devices a. Wire in Conduit 1) Check for insulation and jacket damage. Replace damaged conductors. 2) Proper color coding. 3) Wire markers installed. b. Metallic Sheathed Cable 1) Check for insulation and jacket damage. Replace damaged cable. 2) Check for metallic sheath damage, kinks, flattening and breaks. Replace damage cable. 3) Cable adequately supported by appropriate means.			

SYSTEM	DATE PERFORMED	SIGN-OFFS ELEC.	SIGN-OFFS GC
4) Cable terminations fit tightly, are watertight without use of externally applied sealing compound ground screws are tight. c. With equipment de-energized, test conductor insulation resistance of the systems listed below. Readings shall be taken and recorded between phases and between phase and ground. 1) Motor feeders at load side of starter with motor connected.			
2) Feeders to distribution panelboards with branch feeders open. 3) Branch feeders from distribution panelboards.			
4) Lighting feeder with feeder breaker, transformer and branch panelboard connected, but with branch circuit open. 5) Motor control centers with pushbuttons and overcurrent devices connected, phase to ground only. d. Verify that minimum values of insulation resistance obtained for systems operating at 600 volts or less, using 500 VDC test voltage, are greater or equal to the following: 1) For circuits of No. 12 AWG or smaller, 1 megohm 2) For circuits of No. 10 AWG or larger, as follows: Ampere Capacity — Minimum Insulation Resistance - Ohms 25-50 — 250,000 51-100 — 100,000 101-200 — 50,000 201-400 — 25,000 401-800 — 12,000 Over 800 — 5,000			

SYSTEM	DATE PERFORMED	SIGN-OFFS ELEC.	SIGN-OFFS GC
e. Check each outlet installed under this specification for correct polarity, ground connection, correct voltage and correct circuit connection.			
3. Grounding System a. Check for damage to cables. Replace damaged cables. b. Check that bolted connections made up tight. c. Check integrity of welded connections. d. Check that exposed cable runs are adequately supported and clamped. e. Test and record resistance of the grounding system by use of the ground megger method. Use a low resistance megger. f. Verify resistance to earth does not exceed 5 ohms.			
4. Lighting Systems a. Check lighting fixtures for adequacy of support and proper location b. Check that all unused conduit openings are plugged. c. Check that fixtures are not located above material or equipment that interferes with output of fixture.			
d. Check for proper ballasting. e. Check lamps are the proper voltage, wattage and type. f. All lamps functioning. Replace burned out lamps prior to final acceptance. g. Check emergency battery ballasts and battery lighting systems installed and functioning per contract plans h. Check fixture globes, guards and reflectors for proper installation i. Check operation of lighting controls and systems for operation per contract plans.			

SYSTEM	DATE PERFORMED	SIGN-OFFS ELEC.	SIGN-OFFS GC
j. Check circuitry agrees with lighting panelboards branch circuit directories and contract drawings.			
6. Security System a. Verify correct location of security system components including control panel, card readers, door magnets, door contacts, security cameras, etc. b. Verify correct system operation			
7. Motor Control Centers Check the following: a. All parts of the assembly are free of dust, scrap metal, wire cuttings, screws and miscellaneous hardware and debris. b. Complete assembly of all components. c. In units that have been split for shipment, that adjacent sections have been properly bolted together. d. In units that have been split for shipment, that all main buses, ground buses, neutral buses and control cables have been reconnected.			
e. Bolted bus connections are tight and screws on wire connections and terminal blocks are tight. f. Bus insulators and supports for dirt, cracks and damage. g. All blocking devices removed from contractors, relays and devices. h. Wiring and components in each compartment agree with job wiring diagrams.			

SYSTEM	DATE PERFORMED	SIGN-OFFS ELEC.	SIGN-OFFS GC
i. Compartment nameplates for accuracy and complete information.			
j. Termination and tightness of all outgoing cables.			
k. Ground cable connections.			
l. All temporary connections removed.			
m. With equipment de-energized, incoming line and feeders open, test and record insulation resistance of main bus with 500 volt megger:			
1) Phase to phase			
2) Phase to ground			
3) Verify minimum values of insulation resistance exceed one megohm.			
n. With equipment energized verify:			
1) Phase sequence of incoming line.			
2) Operation of control switches and indicating lights.			
3) Operation of electrical interlocks.			
4) Operation of ground fault detectors.			
5) Operation of alarms.			
8. Switchboard			
Check that:			
a. All parts of the assembly are free of dust, scrap metal, wire cuttings, screws and miscellaneous hardware and debris.			
b. Complete assembly of all components.			
c. In units that have been split for shipment, that adjacent sections have been properly bolted together.			
d. In units that have been split for shipment, that all main buses, ground buses, neutral buses and control cables have been reconnected.			

SYSTEM	DATE PERFORMED	SIGN-OFFS	
		ELEC.	GC
e. Bolted bus connections are tight and screws on wire connection and terminal blocks are tight.			
f. Bus insulators and supports for dirt, cracks and damage.			
g. All blocking devices removed from relays and devices.			
h. Operation of all key interlocks.			
i. All breakers fit into their compartments.			
j. Termination and tightness of all outgoing cables.			
k. Ground Cable connections.			
l. Setting of relays and protective devices.			
m. Compartment and component nameplates for completeness and accuracy of information.			
n. Indicating light lens cap colors.			
o. All temporary connections removed.			
p. With equipment de-energized, incoming line and feeders open, test and record insulation resistance of main bus with 500 volt megger:			
1) Phase to phase.			
2) Phase to ground.			
3) Verify minimum values of insulation resistance exceed one megohm.			
q. With equipment energized verify:			
1) Phase sequence of incoming lines.			
2) Operation of all control switches and indicating lights.			
3) Operation of ammeter and voltmeters selector switches and all meters.			
4) Operation of electrical interlocks.			
5) Operation of alarms.			
6) Operation of ground fault detectors.			

SYSTEM	DATE PERFORMED	SIGN-OFFS ELEC.	SIGN-OFFS GC
9. Panelboards Check: a. All parts of the assembly are free of dust, scrap metal, wire cuttings, screws and miscellaneous hardware and debris. b. Complete assembly of all components. c. Bolted bus connections are tight and screws on terminals for outgoing leads are tight. d. Ground cable connection. e. Rigidity and firmness of mounting. f. Trip ratings correspond to required value on drawings. g. Panel identification nameplate installed, with complete and accurate information. h. Typewritten circuit directory included. i. All temporary connections removed. j. All unused conduit openings plugged. k. With equipment de-energized, incoming line breaker open and branch breakers closed, test and record insulation resistance of main bus and branch circuits with 500 volt megger: 1) Phase to phase 2) Phase to ground 3) Verify minimum values of insulation resistance exceed one megohm l. Verify that switched circuit agree with circuit directory.			
10. Dry-Type Transformers a. Verify primary and secondary voltage ratings. b. Verify kVA rating. c. Final connection made with flexible metal conduit. d. Check adjustment and record tap settings. e. Verify shielded transformers installed where specified.			

SYSTEM	DATE PERFORMED	SIGN-OFFS	
		ELEC.	GC
f. Ground connection for tightness and ground cable for damage.			
11. Motors a. Check for defects or damage. Notify COE of any defects or damage noted. b. Check that nameplate data conforms to equipment schedules and one-line diagrams. Notify COE of any discrepancies.			
c. Frame properly grounded. d. With equipment de-energized, test and record insulation resistance of motor with 500 volt megger: 1) Phase to phase 2) Phase to ground 3) Verify minimum values of insulation resistance exceed one megohm. e. With equipment energized, check for proper rotation.			

END OF SECTION